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PHYTOPATHOLOGY

VOLUME 20 NUMBER 7

JULY, 1930

FRANK GETCHELL O'DONNELL, 1896–1928[1]

N. REX HUNT

Frank Getchell O'Donnell was born October 20, 1896; married Mary Alberson in December, 1923; received the B. E. degree from Schuylkill Seminary in 1917 and the B. S. degree in plant pathology from Pennsylvania State College in 1920. He was a graduate student of George Washington University and the University of Maryland. In 1920 and at various times previous to his graduation he was a field assistant in potato investigations with the Pennsylvania Agricultural Experiment Station. In April, 1920, he was appointed field assistant with the Federal Horticultural Board, later becoming plant quarantine inspector and soon afterward assistant pathologist, which position he held at the time of his death, January 11, 1928. His death was due to tuberculosis, following pneumonia and pleurisy, brought on by exposure during a storm in the winter of 1924–25, while en route to the University of Maryland, where he was carrying graduate work in biochemistry and plant pathology preparatory to studying the physiology of fungi.

He was a member of A. A. A. S., Virginia Academy of Sciences, American Phytopathological Society, American Society of Bacteriologists, Ecological Society of America, Botanical Society of Washington, Alpha Zeta, and Phi Kappa Phi. He was joint author of "Steam and Chemical Soil Disinfection with Special Reference to Potato Wart," Journal of Agricultural Research 1: 301–363, August 15, 1925; author of "Printing Plate Cultures," Phytopathology 12: 53–54, January, 1922; and "Hot Water Bulb Tank; Cheap Cooker for Hybridizer," Florists' Review 60: 31–32, June 16, 1927. Unfortunately his experimental work, which was being done on a large scale, was, as a whole, unfinished and the results were not published.

Such are the prosaic details of a brief biography, but what manner of man was he? He came from a gifted and long-lived family, and, expecting a long life, was building for the future on a broad foundation. His father, a store proprietor, piano teacher, and successful composer, quit music and has been a Bell Telephone city manager for twenty-five years. As promotions came the family moved from city to city, and young O'Donnell

[1] Read before the Botanical Society of Washington, December 4, 1928.

proceeded to make himself at home on and in the water for miles around, collecting all sorts of plants and animals, using his mother's cupboard, sewing basket, and closets for snake houses and such and filling the living room with aquaria. During his high-school days he cleared $600.00 a year selling fancy fish and aquatics. He also dabbled in chemistry and electricity, took up machine shop practice and wood working, and acted as "trouble shooter" for the telephone company.

In college he had no fastidious fish to feed and took to feeding fungi instead. At the time he quit potato-wart work to undertake seed disinfection studies he was carrying 1,200 cultures of organisms from soil given various treatments. In this and in some of his seed-disinfection work it took literally thousands of petri dishes to keep him satisfied. He had an uncanny knack of getting a pure culture of anything he wanted, from any medium, regardless of its nature or condition. As a pastime he grew hundreds of cultures of various fungi on different media and checked the resulting modifications of color, growth, and spore forms. He also experimented rather extensively on methods of preserving pure cultures in tiny packets and had a high degree of success in preserving such cultures for periods several times as long as any published records for them. The varying actions of such long dormant cultures when again given a square meal were a source of great interest and amusement to him. None of this work was ever prepared for publication.

Mr. O'Donnell was an indefatigable worker, often working half through the night. Most of the articles covered by the 2,000 entries in the bibliography used in the potato-wart work were read at night. He had thousands of bulletins and articles summarized and cross indexed in his private library.

He disdained to run experiments on a small scale, thinking nothing of personally counting 20,000 seeds to set up a series of experiments, such series often being repeated several times. He was a stickler for extreme accuracy. He was ingenious in modifying or creating apparatus to meet his needs. Most of his work was done in testing or proving worthless or inadequate numerous proposed or possible seed treatments. He spent much overtime for several months qualifying as an X-ray operator in order to test recommended seed disinfection by X-rays. He built modified vacuum disinfection chambers and tested numerous dangerous war gases. His pure-culture transfer chamber has been copied by several Government offices and other organizations. His records would have furnished material for several important articles if he had not insisted on exhausting all possibilities of each method and testing and retesting the results before committing himself in a publication.

With his great store of accurate and often first-hand information on many subjects, always gladly furnished to any one interested, it is little wonder that Mr. O'Donnell was constantly asked for help on many and diverse problems. He was busy until ten o'clock of the night he died.

His death was a loss to science because of what he might have accomplished had he been permitted to build on that foundation of thorough preparation in all allied sciences, skill in developing and using apparatus and methods, superaccuracy in all details, and limitless patience and perseverance.

THE CONTROL OF CERTAIN FRUIT DISEASES WITH FLOTATION SULPHURS

M. A. Smith[1]

In the United States nearly all the native sulphur is mined by melting it with steam in the rocks in which it occurs and forcing it to the surface. This sulphur, which has a high degree of purity, is suitable for the manufacture of sulphuric acid and lime sulphur. When ground to sufficient fineness it may be used for fungicidal sprays or dusts.

Flowers of sulphur, the fine powder formed by the condensation of sulphur vapor, has been used extensively as a fungicide. However, due to improved machinery, it is now possible to secure a uniformly fine ground natural sulphur that is as efficient fungicidally as flowers of sulphur.

When ground sulphur or flowers of sulphur is added to pure water it floats on the surface because it does not become wet. By reducing the surface tension of the water with a suitable agent, it becomes possible to wet the sulphur particles and thereby secure a suspension which may be employed as a spray. Wettable sulphurs are now widely used in the United States. They may be safely applied to many types of foliage and, if sufficiently fine, are satisfactory fungicides.

With the introduction of lime sulphur in 1908 in Oregon, a very efficient fungicidal spray was secured. It has remained one of the standard sprays since its first introduction. Owing to the fact that it may cause serious injury under certain climatic conditions, there is a demand for a spray material which combines the high toxicity of lime sulphur with the safety of ground wettable sulphur.

In view of the importance of the degree of fineness of the sulphur particle, it is interesting to note that many attempts have been made to utilize a colloidal form of sulphur as a spray material. Ramsay and Cooke (5) have proposed the precipitation of lime sulphur by sulphuric acid. Young (9) added sulphuric acid to a concentrated solution of sodium thiosulphate by which means sulphur dioxide and free sulphur were produced. Other methods of preparing colloidal sulphurs have been proposed by various investigators. The preparation of colloidal forms of sulphur

[1] This project was made possible with funds supplied by the Koppers Company, of Pittsburgh, Pennsylvania, and administered by the Crop Protection Institute. The writer wishes to express his appreciation to Dr. H. W. Anderson, under whose direction these studies were made, and to other members of the Institute committee who have offered suggestions during the course of the work; and to the Department of Horticulture of the Illinois Agricultural Experiment Station for its cooperation in making available extensive facilities.

to be used on a large scale has not yet been found to be practicable from the standpoint of cost and labor involved in their preparation.

Recently there has been developed in the manufactured gas industry a process, known as liquid purification, by which large quantities of pure precipitated sulphur are obtained. This is known as flotation sulphur and is obtained through a process described by Sperr (7, 8) and Sauchelli (6).

When flotation sulphur leaves the filter press it contains about 50 per cent of water and certain impurities of the gas, namely, sodium thiosulphate and sodium thiocyanate. They are water-soluble, however, and may be easily removed by washing, leaving a pure sulphur cake. There are three types of flotation sulphur known, respectively, as Thylox, Ferrox, and Gray. Thylox sulphur is recovered from the patented Thylox liquid purification process. Ferrox is obtained in the patented iron-oxide liquid-purification process and after it is washed may contain from 2 to 6 per cent iron oxide in a very finely divided state. Gray sulphur is obtained in the liquid purification of water gas and is so called because of its gray color. These sulphurs do not differ from one another in so far as characteristics of the sulphur particle are concerned.

Preliminary experiments relative to the physical and fungicidal properties of one type of flotation sulphur were carried on by de Ong (2, 3) in California. From his results it seemed desirable to carry on further experiments along this line. Accordingly, an investigation of this sulphur was started under the administration of the Crop Protection Institute. The primary object was to carry on laboratory and field studies to determine the physical and fungicidal properties of flotation sulphur. The experiments here reported were those conducted in Illinois, where ample facilities were furnished by the Department of Horticulture of the Agricultural Experiment Station.

PHYSICAL PROPERTIES OF FLOTATION SULPHURS

Size of particles: A direct microscopic examination was made of the size of particles of flotation, ground wettable, ground dusting, and processed sulphur. Mounts of the wettable sulphurs were easily obtained by placing a small amount of sulphur in a test tube, adding water, and agitating vigorously. A few drops of the suspension were then drawn off with a pipette, placed on a clean glass slide, a cover slip was added, and microscopic examination made. The different dusting sulphurs were blown by means of a stream of compressed air onto glass slides. Examination of the dusting sulphurs was made without the addition of a cover slip. Figure 1 shows photomicrographs of wettable and dusting sulphurs. Table 1 contains particle-size measurements of a number of the sulphurs examined.

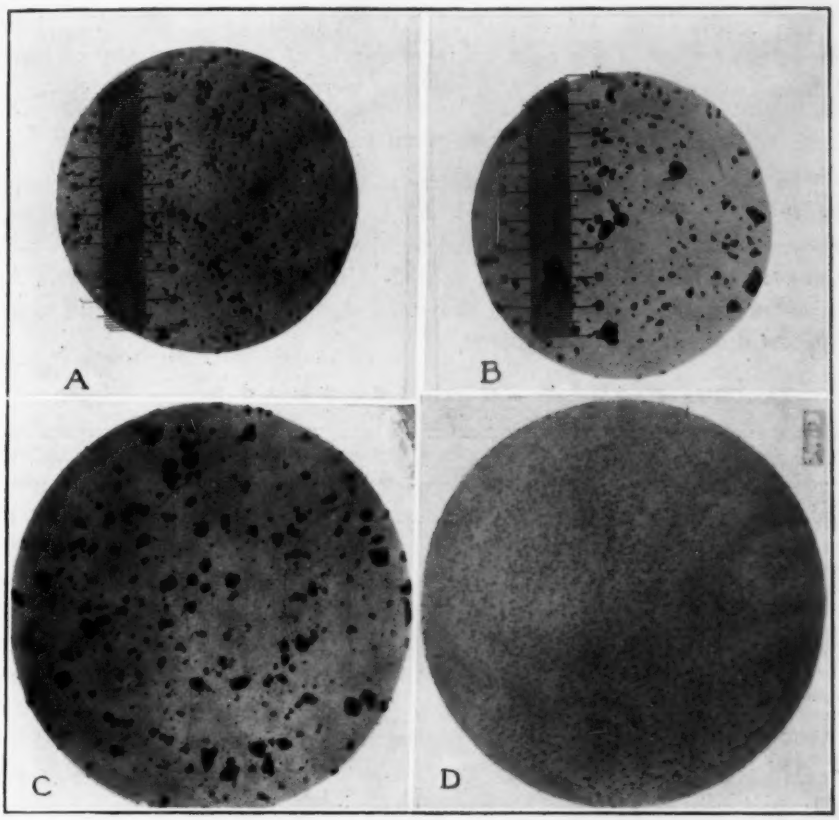

FIG. 1. (A) Flotation sulphur dust ×60; (B) Niagara 200 mesh dust ×60; (C) Niagara Super sulfo dust ×100; (D) Thylox flotation sulphur ×100. (Photomicrographs.)

TABLE 1.—*Comparative size of the particles of certain types of sulphur*

Sulphur	Smallest particles (microns dia.)	Largest particles (microns dia.)	Average size of particles (microns dia.)
Unwashed flotation sulphur[a]	1	5	3
Washed flotation[a] do	1	5	3
Ialine colloidal[a] do	1	3	2
Flowers of do	20	130	39
Mercks precipitated do	6	100	28
Ground roll do	8	200	46
Niagara 200 mesh dusting do	8	87	28
Flotation sulphur dust	3	5	4

[a] Many particles were less than one micron in diameter and too small for accurate measurement.

The results of these tests showed that the particles of Ialine and flotation sulphur were of the most uniform degree of fineness of any of those examined since approximately 95 per cent were 3 microns in diameter.

FOLIAGE INJURY TESTS WITH FLOTATION SULPHUR

The impurities in flotation sulphur as it leaves the filter press consist mainly of small percentages each of sodium thiosulphate and sodium thiocyanate. When each was tested on the foliage of bean plants at percentages ranging from 1 to 15 it caused injury at all concentrations. At concentrations of 5 per cent and above the injury was so severe as to cause complete desiccation of the foliage.

TABLE 2.—*Plant tolerance to unwashed and washed flotation sulphur*

Plant	Sulphur	Concentration	Injury
Bean	Unwashed	1–50	0
Do	do	2–50	Slight
Do	do	3–50	Severe
Peach	do	1–50	0
Do	do	2–50	Moderate
Cherry	do	3–50	Moderate
Apple	do	1–50	0
Do	do	2–50	Slight
Do	do	3–50	Severe
Gooseberry	do	1–50	Slight
Cineraria	do	2–50	Slight
Pelargonium	do	2–50	Severe
Ageratum	do	2–50	Severe
Primula malacoides	do	2–50	Slight
Bean	Washed	1–50	0
Do	do	2–50	0
Do	do	3–50	0
Do	do	4–50	0
Do	do	5–50	0
Do	do	6–50	Slight
Apple	do	2–50	0
Do	do	3–50	0
Do	do	4–50	0
Do	do	5–50	0
Do	do	6–50	0
Do	do	7–50	0
Do	do	8–50	Slight
Cherry	do	3–50	0
Do	do	6–50	0
Peach	do	2–50	0
Do	do	3–50	0
Do	do	4–50	0
Do	do	5–50	0
Rose	do	4–50	0
Do	do	5–50	0
Gooseberry	do	5–50	0
Verbena	do	4–50	0
Geranium	do	5–50	Slight
Cuphea	do	4–50	Slight
Primula kewensis	do	3–50	0

Tests were next made of the effect of unwashed and washed Thylox flotation sulphur on the foliage of a number of different plants. A list of the plants with the concentrations of unwashed and washed flotation sulphur which were tested on them appears in table 2.

The results of this experiment show that unwashed flotation caused injury to foliage in all but two instances when used at a concentration of 2 pounds to 50 gallons. It may be concluded that the impurities present in the unwashed sulphur were responsible for the injury to the foliage of the plants listed in table 2. Apparently the plant tolerance to washed flotation sulphur is much greater since in only three instances was injury observed at the higher concentrations.

DISEASE-CONTROL EXPERIMENTS

Spraying and dusting experiments at Ozark, Ill., in 1928: The use of sulphur dusts and sprays for the control of apple scab was tested at Ozark, Illinois, in 1928. The equipment consisted of a Bean power sprayer and a Bean power duster. In this orchard the trees were twenty-year-old Kinnairds and the plots consisted of 25 trees. The trees were so large that each required eight to ten gallons of spray material. A thousand apples were checked from each plot, the four center trees only being checked, and the apples were harvested in such manner as to obtain fruit from each quarter of the tree.

The results of the spraying experiment at Ozark, Illinois, in 1928, appear in table 3.

The results of the spraying experiments at Ozark show (a) that the standard spray, lime sulphur, was the only one giving satisfactory control of apple scab; (b) the wettable sulphurs, *i.e.*, Ialine, Koloform, Mulsoid, Thylox washed flotation, and Thylox unwashed flotation, at the concentrations used, gave unsatisfactory scab control; (c) injury to the foliage resulted from the use of unwashed flotation sulphur, thus confirming previous experiments which showed that injury resulted from the use of unwashed sulphur; (d) the fruit receiving washed flotation sulphur sprays had a superior finish.

The dusted plots at Ozark consisted of three plots of 36 trees each, so located that dust or spray materials from other plots would not be carried to the trees from which results were to be taken. The dusts were applied early in the morning at intervals corresponding to the spray applications. The three dusts used and the schedule followed were: Plot 16, home-mixed sulphur dust, following standard spray schedule, using 85–15 except in 4- and 6-weeks applications, at which times 100 per cent sulphur was used; Plot 17, Kolotex throughout season; Plot 18, Thylox flotation sulphur dust as in Plot 16—85–15 home-mixed.

TABLE 3.—*Efficiency of sulphur sprays for the control of apple scab. Ozark, Illinois. 1928*

Plot No.	Treatment	Percentage scab		
		Light	Severe	Total
1	Standard spray[a]	9.8	0.7	10.5
2	Unwashed Thylox flotation sulphur 1½–50 Schedule as in (1)	28.5	15.4	47.9
3	Lime sulphur 1–50 in prebloom; unwashed flotation sulphur 1½–50 in subsequent sprays	40.5	5.3	45.8
4	Washed Thylox flotation sulphur 2–50 Schedule as in (1)	36.2	20.2	56.4
5	Lime sulphur 1–50 in prebloom; washed flotation sulphur 2–50 in subsequent sprays	56.0	14.4	70.4
6	Washed Thylox flotation sulphur 3–50 Schedule as in (1)	45.1	7.1	52.2
7	Unwashed Thylox flotation sulphur 2–50 Schedule as in (1)	40.5	15.1	55.6
8	Ialine 1–50 Schedule as in (1)	27.7	10.3	38.0
9	Koloform sulphur 7½–50 Schedule as in (1)	34.0	36.8	70.8
10	Mulsoid sulphur 4–50 Schedule as in (1)	37.0	27.8	64.8
11	Commercial sprayed plot Schedule as in (1)	19.0	6.4	25.4
12	Check	2.0	98.0	100.0

[a] Prebloom (Apr. 10), Calyx (May 3), One week (May 14), Two weeks (May 22), Three weeks (May 31), Four weeks (June 7) ..... Lime sulphur 1–50 and lead arsenate 2–50

Six weeks (June 22), Nine weeks (July 13), 3rd brood (July 28) ..... Bordeaux 3–5–50

Lead arsenate 2–50 and hydrated lime 4–50 used in all applications.

Washed and unwashed flotation sulphurs used in this experiment on dry-sulphur basis.

Table 4 gives the results of the dusting experiment at Ozark, Illinois.

It is apparent from table 4 that none of the dusts was effective in controlling apple scab. Scab infection came late in the season and was very

TABLE 4.—*Effectivness of Sulphur dusts for the control of apple scab. Ozark, Illinois. 1928*

Plot No.	Treatment	Percentage scab		
		Light	Severe	Total
16	Home-mixed sulphur dust Following standard spray schedule, using 85–15 dust (300-mesh) except in 4- and 6-weeks, at which time 100 per cent sulphur dust was used	37.8	48.1	85.9
17	Kolotex—throughout season	16.4	70.1	86.5
18	Thylox flotation dusting sulphur Schedule as standard sprayed plot, 85–15 home-mixed	50.2	20.3	70.5
1	Standard spray plot, lime sulphur 1–50	9.8	0.7	10.5
19	Check	2.4	97.3	99.7

severe throughout this region. Weather conditions also were abnormal. There is a possibility that in a more normal year or in a year when scab infection is not so severe sulphur dust might prove more effective in the control of apple scab. However, these results tend to confirm those obtained by Anderson (1), namely, that dusting cannot be substituted for spraying for the control of apple scab in Illinois.

Spraying and dusting experiments in 1928 at Barry, Illinois: The spraying and dusting experiments at Barry, Illinois, were primarily for the control of apple scab. The orchard consisted of 26-year-old Ben Davis trees. The trees were large, requiring ten gallons of spray material to the tree. The equipment consisted of a Bean power sprayer and a Bean power duster. The sprayed plots contained 20 trees and the dusted plots 40 trees. Scab infection in 1928 was comparatively light, as is usual in this section of western Illinois. The crop was light and scattered due to late spring freezes which had killed most of the buds. A thousand apples from four center trees of each plot were used in determining the amount of scab present.

Table 5 contains the results of the spraying experiments at Barry, Illinois, in 1928. The results of these spraying experiments show (a) that the standard spray, lime sulphur, gave the best control of scab; (b) all wettable sulphurs gave fair control of scab; (c) injury to foliage resulted from the use of unwashed flotation sulphur; (d) in the plot receiving lead and lime, only, throughout the season, the incidence of scab was 44.7 per cent. These results confirm those obtained in previous years in Illinois, viz, that lead and lime are about 50 per cent as efficient for the control

of apple scab as is lime sulphur used at the standard strength. (e) Lime sulphur applied early, followed by Thylox flotation dusting sulphur applied late in the season (Plot 26), gave scab-free apples of excellent finish.

TABLE 5.—*Effectivness of sulphur sprays for the control of apple scab. Barry, Illinois. 1928*

Plot No.	Treatment	Percentage scab		
		Light	Severe	Total
1	Standard spray[a]	0.7	0	0.7
2	Unwashed Thylox flotation sulphur 1½–50. Schedule as in plot (1)	5.9	1.7	7.6
3	Mulsoid sulphur 4–50. Schedule as in plot (1)	6.5	2.7	9.2
4	Washed Thylox flotation sulphur 3–50. Schedule as in plot (1)	8.1	2.9	11.0
5	Koloform sulphur 7½–50. Schedule as in plot (1)	3.7	0.9	4.6
6	Washed Thylox flotation sulphur 4–50. Schedule as in plot (1)	9.3	4.5	13.8
7	Lead and lime Arsenate of lead 2–50 Hydrated lime 4–50	21.9	22.8	44.7
8	Washed Thylox flotation sulphur 6–50. Schedule as in plot (1)	4.0	0.7	4.7
9	Check	27.2	31.9	59.1
26	Lime sulphur 1–50 to nine weeks; flotation dusting sulphur at nine weeks; ten weeks, and three weeks before harvest	0.6	0.1	0.7

[a] Prebloom, Calyx, One week, Three weeks, Four weeks ..... Lime sulphur 1–50; lead arsenate 2–50.

Nine weeks—Bordeaux 2–5–50.

The dusted plots at Barry, Illinois, consisted of 5 plots of 40 trees each, one plot of 25 trees, and one of 15 trees. Dusting was generally done in early morning or in the evening. As in the experiment at Ozark, the percentage of scab was estimated from center trees within the plots. One thousand apples were checked from each plot.

The results in table 6 show that dusting gave only fair control of apple scab. Thylox flotation sulphur dust 85–15 and Thylox flotation sulphur-potassium permanganate dusts were about equally effective in the control of scab.

TABLE 6.—*Effectiveness of sulphur dust for the control of apple scab. Barry, Illinois. 1928*

Plot No.	Treatment	Percentage scab		
		Light	Severe	Total
20	Home-mixed sulphur dust, following standard spray schedule, using 85–15 dust (300 mesh). Pure sulphur alone in prebloom	4.2	2.8	7.0
21	Thylox flotation dusting sulphur 85–15, following schedule as in (20)	5.2	1.9	7.1
22	Thylox flotation dusting sulphur 85–15. Two prebloom applications, followed by 1-wk., 2-wk., 3-wk., 4-wk., 9-wk., 10-wk., and 3d brood applications	7.3	4.6	11.9
23	Thylox flotation dusting sulphur-potassium permanganate-lead arsenate 80–5–15. Schedule as in (20)	3.7	3.8	7.5
24	Kolotex—Schedule as in (20)	20.0	11.4	31.4
25	Kolotex—Schedule as in (22)	18.6	13.5	32.1
27	Check	11.8	8.8	20.6

That these results are somewhat inconsistent may be seen from the fact that flotation dusting sulphur applied seven times gave a total of 7.1 per cent of scab, while in the plot to which nine applications were made there was 11.9 per cent of scab. Furthermore, in both of these plots there was slightly poorer control of scab than in the home-mixed dust plot which had only seven applications of dust but yielded 7 per cent of scabby fruit. Observations made indicated that there was considerable variation in severity of scab in different portions of the orchard. It was noticeable that there was less scab infection at the west than at the east end. Both plots receiving Kolotex were at the east end of the dusted plots. The percentage of scab in these two plots was 31.4 and 32.2, respectively. Since both of these developed between 11 and 12 per cent more scab than the

check plot, it is quite evident that there was more scab in this portion of the orchard.

SPRAYING EXPERIMENTS AT BARRY, ILLINOIS, 1929

The purpose of the experiments at Barry, Illinois, in 1929, was threefold:

To test the fungicidal efficiency of flotation sulphurs; to supplement the later lime-sulphur applications with flotation sulphurs; and to observe the effect of the different sprays on the foliage of apple trees and on the finish of the fruit. The spraying was carried on in a block of 26-year-old Ben Davis apple trees, a portion of which had been used in 1928 in dusting and spraying experiments. The equipment consisted of a Bean power sprayer. About ten gallons of spray material was required for each tree.

Spray materials used were: Commercial lime sulphur, flotation dry mix—a material containing 70 per cent Thylox flotation sulphur and 30 per cent hydrated lime—Sulfuron, a commercial wettable sulphur, and flotation sulphurs of three types, all recovered in the process of gas purification. The use of unwashed flotation sulphur as a summer spray was discontinued in 1929 because of the injury produced from the impurities contained in it.

The spray plots each contained 20 trees. With two exceptions, each treatment was triplicated. Plots receiving similar treatments were located in widely scattered portions of the orchard. This precaution was taken to correct as nearly as possible any differences in scab severity prevalent in certain sections of the orchard. At harvest time a thousand apples were picked from different portions of four center trees of each plot. In estimating scab severity, apples having one conspicuous or two less conspicuous scab lesions were classed as "light scab." When more than this amount of scab was present, it was designated "severe scab." The results of the tests at Barry, Illinois, in 1929, appear in table 7.

Excellent control of scab was obtained in the standard sprayed plot. Moderate spray injury and slight defoliation were observed in the plots receiving this treatment. Good control of scab was obtained in the plots receiving flotation sulphurs. The finish of the fruit from these plots was excellent. No spray injury was observed. In Plots 8, 9, and 10, lime sulphur was used in early applications and washed Thylox flotation sulphur in subsequent sprays. As previously noted, such a schedule was planned for two reasons: (1) Lime sulphur to be used in early applications because of its high toxicity and at a time when scab infection is often most severe; (2) wettable sulphurs to be used in later sprays because of their ability to control scab appearing later in the season. In addition, the wettable sulphur sprays are much less likely to cause spray injury to the fruit and

TABLE 7.—*Effectiveness of sprays for the control of apple scab. Barry, Illinois. 1929*

Plot No.	Treatment	Average percentage scab		
		Light	Severe	Total
1	Thylox flotations dry mix 7½–50 in all sprays	5.93	2.10	8.03
2	Lime sulphur 1–50 in prebloom, flotation dry mix 7½–50 in subsequent sprays	8.47	4.53	13.0
3	Lime sulphur 1–50 in prebloom and calyx, flotation dry mix 7½–50 in subsequent sprays	6.63	3.50	10.1
4	Gray flotation sulphur 5–50 in all sprays	7.10	3.50	10.8
5	Thylox flotation sulphur 5–50 in all sprays	6.07	2.80	8.87
6	Ferrox flotation sulphur 5–50 in all sprays	2.63	0.30	2.93
7[a]	Standard spray, lime sulphur 1–50 in all sprays	3.40	0.11	3.51
8	Lime sulphur 1–50 in prebloom, Thylox flotation sulphur 5–50 in subsequent sprays	4.23	0.83	5.06
9	Lime sulphur 1–50 in prebloom (two applications), Thylox flotation sulphur 5–50 in subsequent sprays	1.62	4.10	5.72
10	Lime sulphur 1–50 in prebloom and calyx, Thylox flotation sulphur 5–50 in subsequent sprays	7.24	4.16	11.4
11	Check	10.83	84.1	94.9
12	Lead arsenate 2–50 and lime 4–50 in all sprays	16.70	35.9	52.6
13	Lime sulphur 1–50 and ferrous sulphate 3/4–50 in all sprays	3.30	0.56	3.86
16	Lime sulphur 1–50 in prebloom, Sulfuron 4–50 in subsequent sprays	15.1	13.0	28.1
A	Commercial-sprayed plot. Lime sulphur 1½–50 in all sprays	5.3	3.1	8.4

[a] Prebloom—(April 12)
Calyx—(April 23)
One week—(May 7)
Three weeks—(May 21)
Five weeks—(June 10)
} Lime sulphur 1–50; lead arsenate 2–50.
Nine weeks—(July 15) Bordeaux 2–5–50.
Lead arsenate 2–50 and lime 4–50 used in all sprays.
All flotation sulphur sprays used on dry-sulphur basis.

foliage, which often occurs when lime sulphur is used through most of the spray season.

Observations during the early part of the spray season showed that the period of maximum scab infection was about ten days later than ordinarily occurs in western Illinois and that the infection was most severe between the time of the calyx and the one-week sprays (April 29–May 4). The smaller percentages of scab in Plots 8 and 9 may have been due in part to the early applications of lime sulphur. On the other hand, the percentage of scab in Plot 10, receiving lime sulphur in the prebloom and calyx applications, was nearly double that in Plots 8 and 9. If lime sulphur was responsible for the decreased amount of scab in Plots 8 and 9, it apparently was ineffective in Plot 10. Inasmuch as the heaviest scab infection occurred after the lime-sulphur applications were made, no definite conclusions may be drawn from this test. However, it is believed that in years when scab appears early in the season the schedule of lime sulphur in early applications followed by wettable sulphurs should prove successful. In Plot 13, receiving lime sulphur and ferrous sulphate, the percentage of scab was about equal to that in the standard sprayed plot. No appreciable reduction in the efficiency of lime sulphur for scab control was observed through the addition of ferrous sulphate. There was, however, considerable

FIG. 2. Apple-spraying experiment. Unsprayed plot on left. Plot to right received flotation sulphur in all sprays.

spray injury from the use of this combination. This is contrary to the results obtained by Dutton and others (4), who report the successful use of iron sulphate and lime sulphur in combination as a preventive of spray injury. Defoliation in the check plots was very severe (Fig. 2). The influence of defoliation on the size of the fruit in this plot was a striking example of the necessity of holding foliage on the trees.

PEACH-LEAF-CURL CONTROL

A cooperative investigation between the State Natural History Survey and the Department of Horticulture at Urbana, Illinois, on the use of certain fungicides alone and in combination with oils for the control of peach-leaf curl and San Jose scale was undertaken in the fall of 1927.

The experiments were conducted in 18 plots in each of three orchards. Each plot contained 20 trees. Two check plots were located in orchard No. 1, two in orchard No. 2, and five in orchard No. 3. In estimating the amount of peach-leaf-curl infection, the following method was employed: An examination was made of at least one check plot in each orchard. The percentage of diseased old leaves was then estimated by examining each tree of the check plot, special attention being given to the inside trees near the center of the plot. New leaves were eliminated in these estimates, since none were diseased in any of the plots. An examination was next made of all the trees in each plot. An average was computed after an examination of all the trees.

Table 8 gives the record of the experiments carried on in the fall of 1927 and spring of 1928.

The results of peach-leaf-curl-control experiments as outlined in table 8 may be summarized as follows: Lime sulphur 1–8 gave very satisfactory control, whether applied in the fall or spring, and this season was effective when applied late in the spring. Oil emulsion with Bordeaux 4–6–50 gave satisfactory control in one orchard and rather poor control in the other two when applied in the fall. The curl control was somewhat less pronounced in two orchards in the spring application, but better in the third orchard. Oil emulsion with 4–50 copper sulphate gave very good control in all cases, in both fall and spring, as well as in late spring this season. It gave slightly more curl in the late-spring application than did lime sulphur. Unwashed Thylox flotation sulphur $7\frac{1}{2}$–50, alone, gave complete leaf-curl control in both fall and spring applications.

Unwashed Thylox flotation sulphur $7\frac{1}{2}$–50 and oil emulsion in a combination spray gave complete leaf-curl control in both fall and spring applications.

At Neoga, Illinois, a block of 900 five-year-old Elberta trees was used for the dormant spray tests. Two materials were used, dry lime sulphur,

TABLE 8.—*Effectiveness of different spray materials in the control of peach-leaf curl at Carbondale, Illinois, 1927–28*

Plot No.	Materials and strengths	Time applied	Percentage peach-leaf curl		
			Orchard No. 1	Orchard No. 2	Orchard No. 3
1	Lime sulphur 1–8	Fall	Less than 1	Less than 1	Less than 1
2	Emulso 3 per cent with lime sulphur 1–20	do	10	5	10–15
3	Scalecide 1–15	do	2	4–5	10–15
4	Oil emulsion 3 per cent with Bordeaux 4–6–50	do	Less than 1	Less than 1	10–15
5	do bluestone 4–50	do	Less than 1	Less than 1	2–3
6	do bluestone 2–50	do	3–4	4–5	5–8
7	do bluestone 4–50	do	3–4	Less than 1	Not applied
10	L–21[a] with unwashed flotation sulphur 15–50	do	No curl	Less than 1	Less than 1
11	L–21 with unwashed flotation sulphur 15–50	do	Not applied	Less than 1	1
13	Same as (1) but applied in	Spring	Less than 1	Less than 1	Less than 1
14	do (4) do	do	1–2	3	4–5
15	do (5) do	do	1–2	Less than 1	1
16	do (6) do	do	4–5	2	5
17	Scalecide, with Sulfocide 1–200	do	20–30	10–20	15–20
18	Same as (10)	do	No curl	Trace in one tree	1
19	Same as (11)	do	Less than 1	Less than 1	5
20	Same as (1) but applied in very late	do	No curl	Less than 1	Less than 1
21	do (5) do	do	No curl	1–2	3–4
Check			N. E. plot 30–50	N. W. plot 40–50	N. W. plot 40–50
do			N. W. plot 20–30	Center plot 10–15	S. W. plot 30–40
do					S. E. plot 30–40
do					E. plot 30–40
do					S. plot 20–30

[a] An experimental oil emulsion, not on the market in which Thylox was the flotation sulphur used.

12 pounds to 50 gallons, and unwashed Thylox flotation sulphur in combination with an oil emulsion prepared by the Standard Oil Company of Indiana. This combination was used at the rate of 7½ pounds of the oil-emulsion-sulphur mixture to 50 gallons. The spraying was done by the owner of the orchard, who used a power sprayer at a pressure slightly over 175 pounds. Spraying was not done until late in March, when the buds were just beginning to open on some of the trees.

The spray materials were applied to six-year-old Elberta trees. Dry lime sulphur was used in spraying eight rows containing 34 trees in each row. Thylox flotation sulphur-oil emulsion was similarly applied to an equal number of trees. Untreated rows were left at both ends and in the center of the block.

On May 17 final observations were made of the percentage of leaf curl in the sprayed and unsprayed rows. These observations showed: (a) 15–25 per cent of leaf curl in the rows receiving dry lime sulphur and oil-emulsion-sulphur sprays; (b) an average of 50 per cent leaf curl in the untreated rows; (c) no injury to the trees from either of these spray materials. From these results it is apparent that the sprays applied were only partially effective in reducing leaf curl. The lateness of application was very likely one of the main factors in the inability to obtain more efficient leaf-curl-control.

A similar test was made at Urbana, Illinois, in the winter of 1928. For this test four rows of seedling peaches were used. All materials (Table 9) were mixed in the field and applied with a Paragon sprayer.

On May 23, a final count was made of the number of curled leaves showing in this block of trees. Table 9 gives the results of the experiment.

TABLE 9.—*Effectiveness of certain sprays for the control of peach-leaf curl. Urbana, Illinois. 1928*

Row No.	No. trees	Treatment	No. curled leaves	Averaged number curled leaves per tree	Percentage leaf curl
1	17	Unwashed Thylox flotation sulphur and oil emulsion 7½–50	9	0.5	1.0
2	17	Dendrol 2 per cent and Bordeaux 4–4–50	20	1.2	2.5
3	18	Dendrol 2 per cent and Oxo-Bordeaux 4–50	180	10.0	20.7
4	12	Check	580	48.3	100.0

This experiment shows that the unwashed sulphur-oil-emulsion combination was highly effective in controlling peach-leaf curl. Though only slightly better than the Dendrol-Bordeaux spray, it was considerably more efficient than the Dendrol-Oxo-Bordeaux combination. No injury was observed from any of these treatments.

PEACH BROWN-ROT CONTROL

During the 1928 season a number of experiments were carried on to test (1) the effectiveness of dusting with sulphur for brown-rot control, (2) the relative merits of various commercial dusting sulphurs and home-mixed dusts, and (3) the relative merits of commercial wettable sulphurs, floatation sulphurs, and dry mix-sulphur-lime and self-boiled lime sulphur. These experiments were carried on in two orchards near Ozark, Illinois. Due to extremely light brown-rot infection throughout this section, no significant differences in brown-rot infection were observed in the treatments. As far as could be ascertained from detailed observations, none of the treatments had any detrimental effect on the foliage or fruit in any of the plots.

TABLE 10.—*Relative effectiveness of certain sprays for the control of brown rot of peach. Carbondale, Illinois, 1929*

Plot No.	Number trees	Treatment	Percentage brown rot
1	25	Dritomic 3–50	3.32
2	31	Sulfuron 3–50	1.88
3	34	New Jersey dry mix 12½–50	0.84
4	33	Self-boiled lime sulphur 8–8–50	1.29
5	28	Thylox flotation dry mix 3½–50	0.65
6	29	Thylox flotafion sulphur 3½–50	0.61
7	35	Gray flotation sulphur 3½–50	0.51
8	25	Mulsoid 4–50	1.75
9	24	"Mist" brand 3½–50	3.04
10	25	Check	17.40
11	19	Koloform 7½–50	4.82
12	20	New Jersey dry mix 1/2 strength (6¼–50)	2.09

Dates of application of sprays:

April 16
do 22
May 10
do 15
June 4
July 2
do 17

In 1929, tests were made of the relative efficiency of various commercial wettable sulphurs, flotation sulphurs, and the standard home-mixed types of sprays, such as dry mix-sulphur-lime and self-boiled lime sulphur. All the commercial wettable sulphurs were used at the maximum recommended strength for peaches. The flotation sulphurs were used at the rate of 3½ pounds to 50 gallons. Self-boiled lime sulphur was used at the recommended strength of 8–8–50. New Jersey dry mix was used at the recommended strength of 12½ to 50 and also at the rate of 6¼ to 50. The spray materials were applied with a Bean power sprayer on the dates listed in table 10. As in previous experiments, the percentage of disease was obtained from fruit picked from center trees of each plot.

In table 10 it will be noted that the percentage of brown rot was small in all the plots receiving sulphur sprays. There were only slight differences among the wettable sulphurs. Apparently, the sprays applied to Plots 3, 5, 6, and 7 were the most effective in reducing brown-rot infection. There was no spray injury observed in any of the plots.

CHERRY-LEAF-SPOT CONTROL

During 1929, an experiment for the control of cherry-leaf spot was carried on in a nursery at Normal, Illinois. The experiment was planned to include the following spray materials: Bordeaux mixture 3–5–50, Ferrox flotation sulphur 6–50, and Gray flotation sulphur 6–50. Each of these materials was applied to two rows of 150 seedlings each of Montmorency cherries. Two rows of 150 trees each were left as checks.

The spray materials were applied with a sprayer of the bucket type. The first spray applications were made on May 29 when no leaf spot was observable. On June 20, at the time of the second application, some leaf spot was noted on a few trees in the check rows. On July 8, at the time of the third application, the disease was generally prevalent, many leaves on the trees in the nonsprayed rows had turned yellow and partial defoliation had occurred. Another application was made on August 9. Almost complete defoliation had occurred in most of the trees in the nonsprayed rows. In the sprayed rows there was no noticeable defoliation and almost no chlorosis had occurred.

On September 15, final observations were made of the sprayed and nonsprayed rows. The results appear in table 11.

From table 11 we may conclude that: (1) Bordeaux mixture 3–5–50 was the most effective of any of the sprays for the control of cherry leaf spot; (2) Ferrox flotation and Gray flotation sulphurs were about equal in fungicidal efficiency in this experiment.

Thylox flotation sulphur was used in comparison with lime sulphur for the control of cherry-leaf spot in the commercial cherry orchards at the

TABLE 11.—*Effectiveness of certain spray materials for the control of cherry leaf spot on seedling cherries. Normal, Illinois. 1929*

Row No.	Number trees	Treatment	Percentage defoliation
1	150	Ferrox flotation sulphur 6–50	4.0
2	150	do	5.0
3		Gray flotation sulphur 6–50	7.0
4	150	do	9.0
5	150	Check	75.0
6	150	do	85.0
7	150	Bordeaux 3–5–50	2.0
8	150	do	1.0

University fruit farm at Urbana, in 1929. This disease was successfully controlled with both of these materials until mid-season. No difference was observed between the two plots, both retaining a greater part of their foliage, while on nonsprayed trees severe defoliation had occurred at this time.

While these results represent only one season's work, they indicate the practical value of flotation sulphurs not only on nursery stock but on commercial cherry plantings. They may be applied when other sprays would injure the foliage or mar the fruit.

SUMMARY

1. A new type of sulphur, called flotation sulphur, obtained in the Koppers Liquid Purification Process of manufactured gas, was investigated. A preliminary report is given.

2. Particles of washed and unwashed flotation sulphur were of uniform fineness, ranging from 1 to 5 microns in diameter. In contrast, the particles of ground sulphur ranged from 6 to 200 microns in diameter.

3. Unwashed flotation sulphur produced injury to foliage because of the presence of the soluble impurities, sodium thiosulphate and sodium thiocyanate, which it contains.

4. In experiments conducted in the greenhouse, flotation sulphur washed free of impurities was safely used at concentrations higher than is ordinarily applied in fungicidal sprays. In field experiments in 1928 and 1929, no injury to foliage or fruit occurred when washed flotation sulphurs were used.

5. Apple-scab-control experiments with flotation sulphurs in southern Illinois in 1928 on a variety especially susceptible to scab were not successful. This may be ascribed in part to the low concentrations used.

6. In 1929 at Barry, Illinois, satisfactory control of apple scab was obtained with all types of flotation sulphur used.

7. No definite conclusions may be drawn from experiments as to the value of prebloom and calyx sprays of lime sulphur followed by flotation sulphur in remaining sprays. Failure to obtain more definite results on this point was probably due to the late appearance of apple scab in western Illinois in 1929.

8. The finish of the fruit from the plots receiving flotation sulphur sprays was good.

9. In the spraying experiment at Carbondale, Illinois, in 1929, the three types of flotation sulphur used gave somewhat better control of brown rot than did several brands of ground wettable sulphur.

10. Unwashed flotation sulphur, in combination with an experimental oil emulsion, satisfactorily controlled peach-leaf curl in experiments carried on in southern and central Illinois in 1927–28 and 1928–29.

11. Three types of flotation sulphur were used in cherry-leaf-spot-control experiments on nursery and commercial cherry plantings in 1929. Satisfactory control of the disease was obtained in these experiments.

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SOME SPECIES OF ATROPELLIS AND SCLERODERRIS ON CONIFERS IN THE PACIFIC NORTHWEST

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INTRODUCTION

Observations in the western part of Oregon, Washington, and British Columbia during the field seasons from 1923 to 1929 show that species of Atropellis (described as a new genus below) and Scleroderris are constantly associated with serious canker-like diseases of conifers. These observations have been made chiefly by workers in the Office of Forest Pathology and the Office of Blister Rust Control of the U. S. Department of Agriculture. With the advent of scouting for white pine blister rust, more particular attention has recently been called to the very deleterious effects of one of these affecting the western white pine, *Pinus monticola* D. Don., in many localities west of the Cascade Mountains and in Idaho. One example of this canker has recently been found on lodgepole pine,[1] *P. contorta* Loudon, and one on sugar pine, *P. lambertiana* Douglas.[2]. In Oregon a species of Scleroderris is believed to cause a canker of *Abies grandis* Lindl. and *A. amabilis* (Loudon) Forbes. For some time the fungus on the canker of western white pine and lodgepole pine has been referred tentatively by some mycologists to *Scleroderris bacillifera* (Karsten) Saccardo and to *S. treleasei* Saccardo by the writers. In order to throw some light on the taxonomy of these western species, the writers have made a comparative study of the fungi believed to cause these cankers of Abies and *P. monticola,* the type of *S. treleasei* which probably occurs on the bark of the Sitka spruce, *Picea sitchensis* (Bong.) Carrière, and a collection of apparently authentic *S. bacillifera.* The present paper discusses the economic importance of these diseases of *A. grandis, A. amabilis, Pinus contorta,* and *P. monticola* and also the comparative anatomy and taxonomy of the three species mentioned above.

[1] Common names of trees used in this paper are those used by Sudworth. Check list, Forest Trees of the U. S. U. S. D. A. Misc. Circ. 92. 1927.

[2] After this paper went to the editor, L. N. Goodding collected 75 cankers of *Atropellis pinicola* on sugar pine from just above Slate Creek in the Siskiyou Mountains, Josephine County, Oregon, February 17, 1930. On these cankers the pycnidia of *Fuckelia pinicola* were associated with *Atropellis pinicola.* The cankers have the same appearance as those described on *Pinus monticola.* The collection is Oregon Agricultural College Herb. No. 4886, Zeller Herb. No. 7611, and cankers have been sent to the U. S. Office of Forest Pathology, Portland, Oregon, and to Dr. J. S. Boyce, Yale University.

DISTRIBUTION AND ECONOMIC IMPORTANCE OF THESE FUNGI

So far as is known to the writers, *Scleroderris treleasei* has not been reported since the collection of the type in 1899. This was taken at Sitka, Alaska, by Dr. Wm. Trelease, and a collection by Prof. Trevor Kincaid taken at the same time was reported by Saccardo. There is a very small portion of the bark of the host with the type material in the Herbarium of the Missouri Botanical Garden. This is believed to be bark from the Sitka spruce, *Picea sitchensis*. No statement is made concerning its host relationship, whether parasitic or saprophytic.

The fungus on western white pine, *Pinus monticola*, has been found from Lane County, Oregon, north into British Columbia and eastward into Idaho. It perhaps occurs throughout the range of the host where moisture and temperature conditions are conducive to infection. The type locality perhaps should be designated as the Pacific Slope of British Columbia, Washington, and Oregon, although the type collection was taken near Quilcene, Jefferson County, Washington.

In locations where trees are infected the cankers may be only occasionally found or may kill many twigs and branches on small trees from 4 to 40 feet high. For the most part no infections are found on the main trunk of larger trees, but symmetrical growth of small trees is often prevented by cankers which kill out the main leader up where the diameter is small. The largest trunk cankers reported were about breast-high on trees 3 and 5 inches in diameter. Trees smaller than this often are killed by cankers girdling the trunks. Collectors scouting for white pine blister rust report that dead twigs and branches of *P. monticola*, killed by this fungus, closely resemble blister-rust "flags." In some localities in the Olympic National Forest, Washington, and the Mt. Hood National Forest, Oregon, very heavy infections are to be found. Individual trees up to 40 feet high may have many of their smaller branches and twigs killed by numerous cankers. On the smaller branches and on larger branches sunken cankers often occur on but one side of the branch and during the spring the bark on the last two years' growth of the cankers is usually spotted with numerous black apothecia of the fungus. Branches only partially girdled are nearly always thrifty but die when the girdle is complete.

The same fungus which occurs on *P. monticola* has been found but once on *P. contorta*. This one collection of 12 cankers from northern Coos County, Oregon, has given little opportunity to observe its economic importance on this host.

The Scleroderris on lowland white fir (*Abies grandis*) has been found in the Northwest in three locations, namely, at the head of Wilson River in Tillamook County, near Kingston in Linn County, and near Bayview, Lincoln County, Oregon. Most of the fir trees of this species are infected

in a limited area at the head of Wilson River. Further observations made since the discovery of the disease lead to the belief that the virulence of infection varies from year to year.

Twigs and branches, and trunks of trees up to 4 inches in diameter have been found affected with cankers of various sizes. There is no indication of growth of the canker after the initial year, so that the economic importance of its damage is not comparable to that caused by the perennial growth of the fungus attacking western white pine.

The same species of Scleroderris occurs on silver fir, *A. amabilis*, in Hood River County, Oregon. It has been reported from the one locality only. Apparently the damage is much less severe on this host than on *A. grandis*.

INFECTION AND PATHOGENECITY OF THE FUNGUS ON PINUS MONTICOLA

It is not known just when infection takes place, but some collections taken in May show some very small cankers, 6 to 7 mm. in diameter. These appear like late infections after the host tissues have begun to grow. The growing tissues of the host have excluded the further advance of the fungus by a cork layer before the infection reached the cambium. This would lead to the belief that for normal development of typical cankers the infection would take place in the fall or early winter. Another observation leading to the belief that infections take place in the fall is the fact that the excipular enclosures of the apothecia rupture when moistened artificially. Apothecia on the two-year-old ring of canker development are mature and open, many of them having discharged their spores. Those on the last year's canker development are mature but not open. These were collected from March to August. Since these latter apothecia are mature and readily rupture and expand upon the application of water it would seeem that ascospore liberation would take place with the first continued rains in the fall and the natural supposition would be that infection would follow during the dormant period of the bark and cambium of the host.

No attempts have been made to induce infection and canker formation by artificial inoculation. Our observations on pathogenicity of this organism causing the canker of *P. monticola* were made wholly from cankers induced under natural conditions of infection. It is not difficult to deduce from such observations, however, that this species is quite parasitic in nature. Most infections are apparently through uninjured bark or leaf-scars. Crotch infections are rather numerous. In many of these the smaller lateral branches are dead. It is believed that most of this "flagging" is caused by the canker. In fact, there is no indication that infection ever takes place through dead twigs. On the contrary, there is considerable evidence that the fungus does not grow saprophytically in the dead portions

of branches killed by girdling cankers. In cases where cankers have caused such dead flags one never finds apothecia beyond the limits of the last year's advance of the canker.

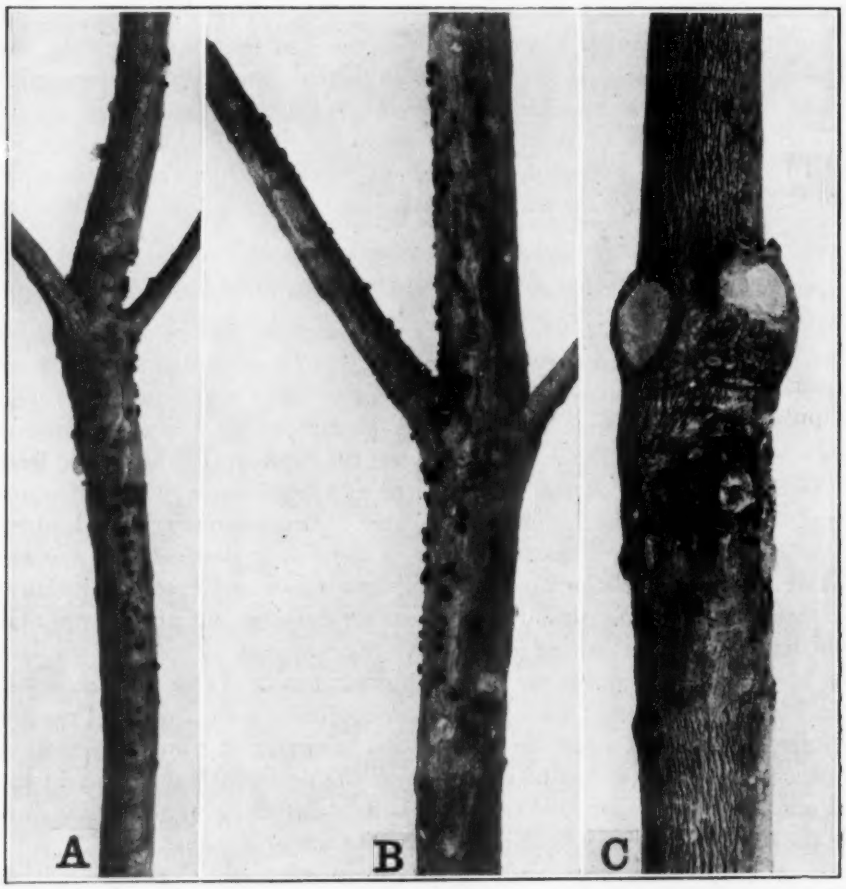


FIG. 1. Cankers on *Pinus monticola* with which *Atropellis pinicola* is associated. A. Three-year-old canker. The black bodies are apothecia. This canker was collected in November and shows no apothecia on the youngest or outer ring of dead wood. B. Three-year-old canker. Note the concentric rows of apothecia on the different ages of cankered bark. There are some pycnidia in the outer row of fruiting bodies. Collected in August. C. *Fuckelia*-stage collected in June, 1923, by H. G. Barstow at Chico, Kitsap County, Washington. Slightly reduced.

DESCRIPTION OF CANKERS ON PINUS MONTICOLA

The typical branch canker on *Pinus monticola* is caused by the killing of the cortex in long strips extending lengthwise of the limb (Fig. 1, A and

B). The affected tissues of the canker becomes somewhat sunken, but there is not an extreme shriveling nor separation from the surrounding healthy bark. Thus, for a number of years, the canker remains closed. The disease is progressive or perennial and year after year the canker encroaches upon the surrounding healthy bark. The greatest canker enlargement, for the most part, is lengthwise of the stem rather than around it. For instance, a canker 10 cm. long on a branch 1.5 cm. in diameter will be about ¼ as broad and may extend 3 cm. at each end during the second year, while advancing merely 6 to 10 mm. laterally during the same period.

Generally, the cankers are rather smooth, giving a flattened appearance to the side of the branches harboring them. On three-year-old cankers the central or oldest portion of the canker is usually dotted with disintegrating apothecia of *Atropellis pinicola*. The second year of the canker is marked by a line of mature, open apothecia arranged concentrically around the older portion, while on the last year's growth or youngest portion of the canker are to be found apothecia with mature asci but in which the excipulae have not yet ruptured above the hymenia. This is particularly true in cankers observed before the first rains in the fall of the year. Often on this last year's growth are to be found the black stromata of what we believe to be the imperfect stage. We have not demonstrated the organic connection between this imperfect stage and the ascogenous stage but their constant association on cankers gives circumstantial evidence. The only evidence of the causal organism on some one-year-old cankers is this pycnidial form (Fig. 1, C).

The cankers on *P. contorta* are very similar in appearance to those on *P. monticola*.

Cross-sections of cankers show rather deep staining of the wood. This stain is bluish black, reminding one of the stain produced by *Cenangium piniphilum* Weir. It occurs in the wood of both *P. monticola* and *P. contorta*.

INFECTION AND PATHOGENICITY OF THE SCLERODERRIS ON ABIES

As is true of the fungus attacking western white pine, the organism attacking *Abies grandis* and *A. amabilis* apparently should be considered a true parasite. In most of the cankers examined, if not all of them, infection took place through uninjured bark or leaf scars, so far as can be determined. The same arguments given to indicate that the infection on western white pine takes place in the fall of the year after continuous rains have begun hold also for infection by the fungus causing canker on fir. There are no indications of the fungus growing saprophytically under natural conditions.

DESCRIPTION OF CANKERS ON ABIES

In the main it would seem that this canker develops much more rapidly on *Abies grandis* than the one on western white pine. The development of the canker on *A. amabilis*, however, seems to be much slower than that on *A. grandis*. The spots develop continuously after once started during the dormant period of the host.

On *A. grandis*, the cankers are very smooth, there being no appearance of concentric zonation due to alternatng periods of rapid and slow growth (Fig. 2, A, B, and C). In early spring when canker enlargement ceases, the bark of the diseased areas dries and sinks, and often cracks longitudinally due to radial and tangential shrinkage. This condition, together with the normal growth of callus in the surrounding bark and wood, produces a tension which results in the formation of a crack in the bark at the

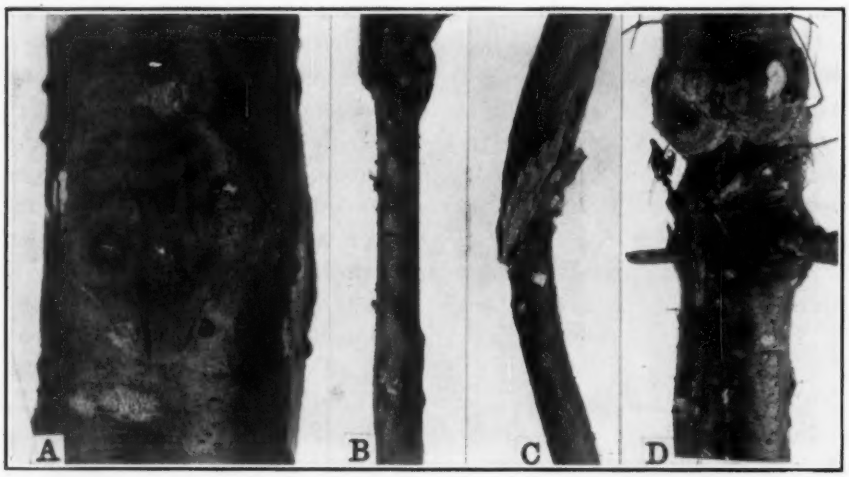


FIG. 2. Cankers on *Abies grandis* with which *Scleroderris abieticola* is associated. A. Young canker collected in October shows mature apothecia. Natural size. B and C. Small branches constricted by cankers become enlarged above when girdling it not complete or when the wood cylinder remains alive. Natural size. D. Old canker on a 4-inch trunk. ½ diameter.

edge of the canker (Fig. 2, C). It is quite evident that the spread of the fungus ceases as soon as the cambium becomes active in the spring. These young cankers have a reddish brown color. Young cankers, collected May 24, 1928, show no apothecia, while young cankers collected October 18 show apothecia well developed but not yet dehiscent. This leads to the assumption that apothecia are developed during the summer of the first year of the canker. Observations so far show that the canker does not

develop farther than the first year's growth. The dead bark usually falls away during or after the second year and, if the branch or bole is not girdled the first year, the wound becomes completely calloused over.

On *A. amabilis* the cankers on young branches are very similar to those on *A. grandis,* showing the same type of constriction. The limited material available does not show the callus formation and cracking along the margins of cankers as illustrated by much of the material on *A. grandis.* One canker from a larger branch shows callus formation and marginal cracking and also indicates that the cankers do not increase in size after the first year.

TAXONOMY

After a study of the morphology of the fungi involved in the diseases discussed in this paper, we present herewith the following diagnoses. The first conception of the writers in their study of the three fungi involved was to refer them to Scleroderris Fries. There is apparently no question that the species on Abies should be so referred. We believe this to be distinct from other described species and therefore propose for it the name *S. abieticola,* sp. nov. Saccardo's *S. treleasei* and the fungus causing canker of *Pinus monticola* and *P. contorta* differ from the usual conception of the genus Scleroderris in two well-defined characters, *i. e.,* nonseptate spores and the color of the paraphyses and hymenium. We therefore refer these two species to a new genus, Atropellis. Saccardo's[3] statement relative to *S. treleasei* shows that he had leanings in this direction. He placed the species in the Dermateaceae but appended the following note (translated from the Latin): "Its relationships are a little doubtful, tending in some respects toward *Clithris,* in others toward *Coccophacidium* and in still others strongly toward a new generic type." In the Sylloge Fungorum he later added the clause "connecting closely with the Scolecosporae near Godronia."

ATROPELLIS Zeller & Goodding, gen. nov.[4]

Apothecia erumpent, single or caespitose from an inconspicuous stroma, sessile or stipitate, cupulate to broadly discoid, closed, at length laciniately-dehiscent, externally smooth to roughened, dark; *hymenium* variously colored; *asci* cylindrical to slightly clavate, 8-spored; *spores* filiform to acicu-

[3] Harriman Alaska Expedition, 5: Crypt. Bot. 1904.

[4] *Apothecia* erumpentia, singulares vel caespitosae, e stromatibus inconspicuibus, sessiles vel stipitatae, cupulatae ad disciformes; primere clausae, ultimate dehiscentesque laciniatae; exterior apothecii ater, levis vel asper; *hymenium* varie coloratum; *asci* cylindracei aut clavati anguste, octospori; *sporidia* filiformia vel aciculares, continua, hyalinia; *paraphyses* filiformes, simplices vel furcatae; ascos excendentis tenuiter aut extendatae et epithecium formatis, coloratae clare et varie; excipulum carbonacium; hypothecium crassum.

lar, continuous, hyaline; *paraphyses* filiform, simple or furcate, slightly exceeding the asci or extended and forming an epithecium, distinctly and variously colored; excipulum carbonaceous; hypothecium well developed.

The type species is *Atropellis pinicola* Zeller & Goodding.

Because of the thick, well-developed hypothecium or medullary tissues of the apothecia, the genus Atropellis belongs in the family, Tryblidiaceae. With Scleroderris it forms a scolecosporous group within the family and is related to other families of the Discomycetes through genera having needle-shape spores.

1. **Atropellis treleasei** (Sacc.) Zeller & Goodding comb. nov. *Scleroderris treleasei* Saccardo, Harriman Alaska Expedition, Vol. 5, Crypt. Bot., p. 24. *Pl. 3, fig. 7a–g.* 1904.

Apothecia solitary, or gregarious, at first erumpent, then entirely superficial, mostly sessible, at first pitcher-shaped, closed, then scutellate, laciniately-dehiscent, 2.5–4 mm. in diameter, expanding to 3–5 mm. when moistened; *outside* and *margins* torn, dusky purplish gray (Ridgway), carbonaceous, rugose; *hymenium* flatly-concave to convexly expanded, waxy, "pinkish cinnamon to Sayal brown" (Ridgway); *asci* clavate with obtusely-acute apices, narrowly and long stipitate, 100–178 x 8–14 μ (average 100 μ without stipe, 167 μ with stipe), eight-spored, staining brown with iodine; *paraphyses* filiform, with simple or incurved, furcate tips which very slightly exceed tips of asci, hyaline; *epithecium* none; *spores* fasciculate in upper part of ascus, mostly filiform, often somewhat clavate, hyaline, continuous, 42–60 x 2–2.5 μ; *hypothecium* a thin layer of light brownish prosenchyma underlaid by a slightly thicker layer of thin-walled, hyaline pseudoparenchyma which becomes less distinct toward the margin of the disc. The *excipulum* is composed of pseudoparenchyma in 3 layers in most specimens. The ectal layer is thin, dark brown (almost black), of small, polygonal cells with heavy walls. The layer just inside of this is of lighter brown cells of the same shape but a little larger. In some specimens the medullary hyaline tissue is a meshy pseudoparenchyma, as shown in plate I, B), but in others the type of pseudoparenchyma just above it extends to the second ectal layer just below. The *stem* is of the same structure as the excipulum. The stem arises several cells deep in the cortex of the bark.

On bark of *Picea sitchensis* (?); Alaska. The type was collected June, 1899, and, so far as the writers are aware, no other collections have been reported.

Specimens examined: Alaska: Baranof Island, Sitka, June, 1899, *William Trelease,* 845, type of *Scleroderris treleasei* (in Missouri Botanical Garden Herb.).

Godronia splendida Speg. must be closely related to *A. treleasei* and perhaps should be referred to Atropellis. It is described as having a beautifully golden hymenium and continuous spores.

2. Atropellis pinicola Zeller & Goodding, sp. nov.

Apothecia solitary or gregarious, erumpent from outer cortical layers of bark, sessile or on very short central stalk, 2–4 mm. in diameter, at first closed, opening by stellate or irregular clefts, leaving rather fimbriate margins, expanding discoid, usually rolling up from two sides when drying, externally pruinose, black to fuscous-black; *hymenium* pruinose, black; *asci* clavate, hyaline, staining brown with iodine, 8-spored, 74–178 x 8–13 μ (average 100 x 11 μ); *spores* filiform to acicular-clavate, hyaline, continuous, guttulate, 32–63 x 1.5–3.5 μ, (average 40 x 2 μ); *paraphyses* hyaline, hair-like, flexuous, exceeding the length of the asci by 32–38 μ, tips slender, agglutinated, forming a dense *epithecium* with rosy and purplish tints in section; *hypothecium* well developed, of dark brown, fascicled hyphae, extending mostly centrifugally upward from a hyaline, prosenchymatous, medullary portion of the apothecium; *excipulum* a prosenchyma, the ectal portion of which is composed of coarse, very dark-walled hyphae, which gradually shade lighter toward the hyaline medullar tissue.

Imperfect stage usually associated with *A. pinicola:*

Fuckelia: Stromata erumpent, sometimes scattered, mostly gregarious, black, pulvinulate, sessile to short-stipitate, 0.8–1.2 mm. in diameter, containing 16–35 locules (pycnidia); *stromatic tissue* of pseudoparenchyma surrounded by a carbonous rind of the same structure; *stipe* of same structure; *pycnidia* ovoid to globose, somewhat crowded, mostly in one plane, walls prosenchymatous, lining the stromatic pseudoparenchyma, 60–150 μ broad, 200–260 μ deep, ostiolate; *ostiole* slightly papillate, 25–32 μ in diameter; *conidiophores* from entire inner surface of pycnidia, hair-like, simple, and branched; *conidia,* hyaline, continuous, narrowly ellipsoid to bacillar, 8–11 x 1.7–3 μ.

To our knowledge this is the first report of a Fuckelia on conifers. There were previously three species described, two of which are designated as imperfect stages of species of Cenangium. None of the three, however, agrees in description with this one. Should this prove to be organically distinct from *Atropellis pinicola* it should be designated as *Fuckelia pinicola* Zeller & Goodding.

The pruinose character of the exterior of the apothecium is due to ectal hyphae projecting somewhat from the surface in tufts. In young closed specimens the excipulum is continuous over the top enclosing a collapsed mass of dark hyphae above the epithecium. This mass disappears when the excipulum ruptures above.

Associated with canker on living branches and trunks of *Pinus monticola* and *P. contorta.* Collections with the fungus in fruiting condition have been taken throughout the year. Oregon, Washington, Idaho, and British Columbia.

Specimens examined:

Montana: Flathead County, Olney, July 25, 1927, *C. R. Stillinger,* 2608 (in Zeller Herb., 7481).

Idaho: Clearwater County, Elk River, July 12, 1924, Sept. 1, 1928, and Sept., 1924, *C. R. Stillinger,* 593, 2605, 2609 (in Zeller Herb., 7476, 7475, 7474); Jericho, July 5, 1925, *C. R. Stillinger,* 544 (in Zeller Herb., 7477).

Oregon: Clackamas County, Government Camp, Jan. 1, 1927, *J. S. Boyce,* 1730 (in Zeller Herb., 7538, For. Path Herb.,[5] 40339); Still Creek, near Government Camp, July, 1927, *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4931, and Zeller Herb., 7095); Rhododendron, May 30, 1924, *J. S. Boyce,* 1304 (For. Path. Herb., 40338); July 9 and 10, 1929, *G. D. Darker,* and *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4874, 4875, and Zeller Herb., 7574, 7575); June 9, 1927, *L. N. Goodding* and *R. L. McLeod,* For. Path. Herb., 40390 (in Zeller Herb., 7163, and Ore. Agr. Coll. Herb., 4921); Zig Zag, Mt. Hood, July 11, 1926, *H. G. Lachmund* (For. Path. Herb.); Zig Zag Ranger Station, April 6 and May 15, 1929, *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4876, and Zeller Herb., 7576 and 7578); July 11 and 15, 1929, *G. D. Darker* and *L. N. Goodding,* Yokum Falls (in Ore. Agr. Coll. Herb., 4877, and Zeller Herb., 7577, 7573); Coos County, ten miles south of Reedsport, Nov. 24, 1929, *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4882, in Zeller Herb., 7589); Lane County, near Summit, McKenzie Pass, July 29, 1928, *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4930, and Zeller Herb., 7457); Linn County, Pine Ridge, Big Meadows, July 16, 1926, *F. P. Sipe,* 40 (in Ore. Agr. Coll. Herb., 4878, and Zeller Herb., 7023); Wasco County, Barlow Creek Canyon, Aug. 10, 1928, *E. L. Evinger* (in Ore. Agr. Coll. Herb., 4929, and Zeller Herb., 7458).

Washington: Clallam County, Lake Crescent, Aug. 11, 1926, *J. S. Boyce* 1679 (For. Path. Herb., 40375); Jefferson County, Irondale, May 5, 1926, *L. N. Goodding* and *F. A. Patty* (in Ore. Agr. Coll. Herb., 4928, and Zeller Herb., 7086); Quilcene, Mar. 7, 1926, *S. B. Detwiler* and *L. N. Goodding,* type (in Ore. Agr. Coll. Herb., 4927, Boyce Herb., 1635, and Zeller Herb., 6892); Kitsap County, Chico, June 7, 1923, *H. G. Barstow* (in For. Path. Herb., 40389); Mason County, Sept. 3, 1927, *C. R. Stillinger,* 2606 (in Zeller Herb., 7473); Pierce County, Ashford, Aug. 16, 1927, *C. R. Stillinger,* 2607 (in Zeller Herb., 7471); near entrance to Rainier National Park, Aug. 15, 1927, *C. R. Stillinger,* 2610 (in Zeller Herb., 7472); Skamania County,

[5] In each of these cases, reference is made to the accession number in the herbarium of the Office of Forest Pathology, Post Office Building, Portland, Oregon.

above Wind River Forest Nursery, June 19, 1928, *L. N. Godding* (in Ore. Agr. Coll. Herb., 4926, and Zeller Herb., 7459); Nov. 28, 1927, *C. C. Strong* (in Ore. Agr. Coll. Herb., 4925, and Zeller Herb., 7460); Willard, June 12, 1924, *J. S. Boyce,* 1305 (in For. Path. Herb., 40340).

Canada: British Columbia, upper Birkenhead River Crossing, Cabin on Prohibition Claim Trail, Mile 72, P. G. E., May 25, 1927, *C. N. Partington* (in For. Path. Herb., 40426); upper Birkenhead River Valley, on Birkenhead Tenquil Trail, Mile 72, P. G. E., Sept. 1, 1927, *C. N. Partington* (in For. Path. Herb., 40427).

SCLERODERRIS FRIES

1. Scleroderris abieticola Zeller & Goodding, sp. nov.

Apothecia single or gregarious, from an erumpent stroma (or single apothecia erumpent from outer cortical layers of bark), on short central stalk, seldom sessile, 0.5–1.2 mm. in diameter, at first closed and spheroidal or ellipsoidal, opening by stellate or irregular clefts, then cupulate to expanded, externally smooth to flaky, grayish black to shiny black; *hymenium* shiny slate color to shiny black; *asci* clavate, hyaline, stained brown with iodine, but bore at tip blue, usually 8-spored, rarely 4-spored, 118–135 x 9–14 μ (average 129.5 x 11 μ); *spores* filiform, many guttulate, distinctly 5–8-septate, hyaline, 40–67 x 3.5–4.5 μ; *paraphyses* hyaline, hair-like, tips slightly enlarged, slightly exceeding the length of the asci, somewhat agglutinated but not forming an appreciable epithecium; *hypothecium* hyaline, composed of a thick, very gelatinous prosenchyma; *excipulum* with a black rind, underlaid by several layers of differentiated pseudoparenchyma. The excipulum extends downward forming the outer layers of the stem. The medullary region of the stem is pseudoparenchyma composed of brown, thick-walled isodiametric cells. From these there is a gradual transition through thin-walled, hyaline, pseudoparenchyma to the hypothecium.

The excipulum exhibits three rather well-differentiated layers with an external rind. The ental layer is pseudoparenchymatous, composed of small, dark, thin-walled, isodiametric cells. The middle layer joins the inner one with a gradual transition to cells appearing like rather small, parallel, light-brown hyphae coalescing to form a typical pseudoparenchyma. The ectal layer resembles the middle layer but the cells are distinctly larger, more barrel-shaped, with light amber-colored walls. The rind seems to be merely a darkened layer of the latter which may flake off, giving the grayish black appearance to some apothecia.

A very interesting phase of abnormal spore formation is sometimes to be observed in this species. Four-spored asci are not infrequently found. In fact, on first observation, the writers believed the species to be characterized by 4-spored asci. In all cases of subsequent examination, how-

ever, we have found the 8-spored asci to greatly predominate. The spores from both the 8-spored and 4-spored asci are distinctly septate. In some cases there are four large spores and four very small spores. These two types of abnormal asci are shown in Plate I, Q. They are usually somewhat shorter than normal 8-spored asci. Spores from 4-spored asci are 85–100 x 4.5–6 μ, while in asci containing four large and four small spores the larger are 70–80 x 4.5–6 μ and the small spores are 11–15 x 4–6 μ.

The writers first believed this Scleroderris, as it occurs on *Abies grandis*, was the same as the European *S. bacillifera*, but it has since been our privilege to study a collection of the latter on *A. pectinata* DC. This Eureopean material was collected in Bavaria, June, 1881, by Britzelmayr and is reported as *Tympanis bacillifera* Karsten on *Picea excelsa* L. This agrees in every way with Karsten's description. *Scleroderris abieticola* differs from this material and the description of the color and structure of the hypothecium, size of asci and spores, and general appearance. If the hyaline, gelatinous layer which we have referred to as the hypothecium could be considered as a medullary portion of the excipulum, the species should perhaps be referred to Godronia.

This species of Scleroderris is associated with cankers on living branches and twigs of *A. grandis* and *A. amabilis*. Collected in January, May, and October. Oregon.

Specimens examined:

Oregon: Hood River County, near Horse Thief Meadows on Mt. Hood Loop Highway, May 20 and July 6, 1929, *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4873, 4920, and in Zeller Herb., 7247 and 7572); Lincoln County, near Bayview, Aug. 30, 1929, *S. M. Zeller* (in Zeller Herb., 7539); Linn County, Kingston, Jan. 6, 1928, *J. L. Mielke* (in For. Path. Herb., 40474, and Zeller Herb., 7470); Tillamook County, Head of Wilson River, May 24 (2 collections), Oct. 18, 1928, and Sept. 16, 1929, *L. N. Goodding* (in Ore. Agr. Coll. Herb., 4932, 4933 type, 4934, 4924, and in Zeller Herb., 7442, 7443 type, 7451 and 7541).

Another species of Scleroderris on *A. amabilis* was collected by G. D. Darker and L. N. Goodding near Horse Thief Meadows, Hood River County, Oregon, July 6, 1929. The material is so meager that we hesitate to refer it definitely to a species at this time. It apparently has close affinities with *S. amphibola* (Mass.) Gill. but differs from the latter in some characters. It seems to be entirely saprophytic.

SUMMARY

This paper describes as new a genus of fungi near Scleroderris in the family Tryblidiaceae. The name Atropellis is proposed for the genus with *A. pinicola* Zeller & Goodding, sp. nov., as the type species. A canker of

Pinus monticola and *P. contorta* with which *A. pinicola* is associated, and a canker of *Abies grandis* and *A. amabilis* with which *Scleroderris abieticola* Zeller & Goodding, sp. nov., is associated, are described and the distribution and economic importance of the two cankers are given. The paper includes diagnostic descriptions of the new genus Atropellis and the three fungi *Atropellis pinicola, A. treleasei,* and *S. abieticola.*

EXPLANATION OF PLATE I

Illustrating the morphology of *Atropellis treleasei, A. pinicola,* and *Scleroderris abieticola.* All drawings sketched to scale by means of camera lucida.

Atropellis treleasei

A. Diagrammatic vertical section of an apothecium, showing relation of parts and relation to host. ×10.

B. Vertical section through the margin of an apothecium, illustrating the structure of the excipulum, medullary tissue, hypothecium and hymenium, ×75.

C. Mature asci and paraphyses. Note the long stipitate asci with fascicle of spores in upper half and note that the length of paraphyses does not exceed that of asci. ×500.

D. Ascospores. ×500.

E. Shows the relation of the spores to the apex of an ascus. ×1500.

Atropellis pinicola

F and G. Two diagrammatic vertical sections of mature apothecia showing relation to host bark and relation of parts. Note in the closed apothecium that the space above the epithecium and within the excipulum is stuffed with a mass of collapsed hyphae. ×10.

H. Vertical section through the margin of an apothecium, showing grossly the morphology of the parts. Note the well-developed *hypothecium* and *epithecium.* ×75.

J. Asci and paraphyses. Note how the latter greatly exceed the length of the asci. ×500.

K. Ascospores. ×500.

L. Diagram of a vertical section of a stipitate stroma of the Fuckelia stage. ×10.

M. Vertical section through half of a pycnidial stroma showing the gross morphology of the parts. ×75.

Scleroderris abieticola

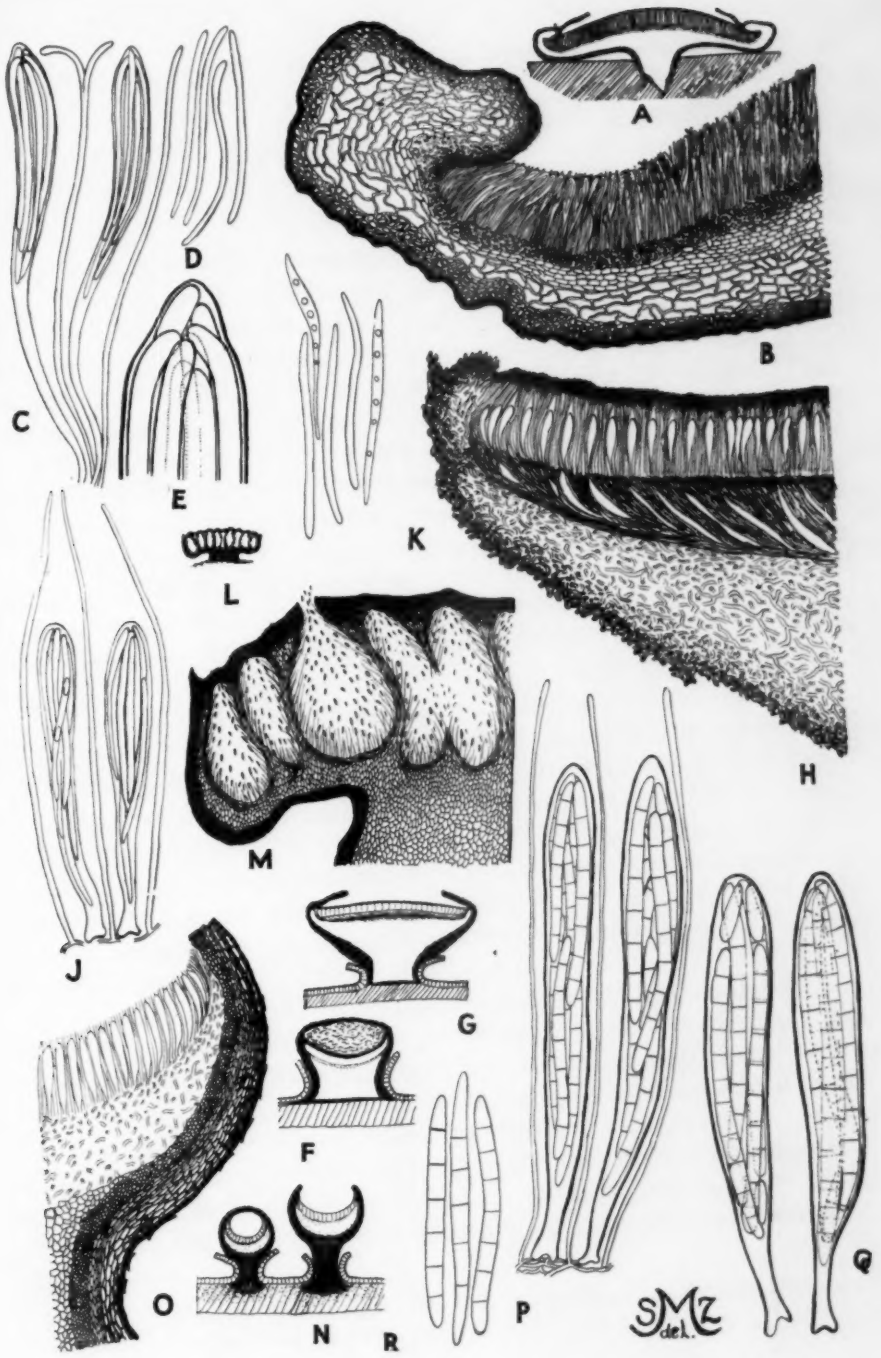
N. Diagram of vertical sections of both a closed and an open mature apothecium. The closed apothecia are almost spherical and more stipitate than in the other two species described here. ×10.

O. Vertical section through half of an apothecium, showing the gross morphology of the parts. Note particularly the complex structure of the excipulum and stipe. The hypothecium is merely a hyaline, gelatinous medullary region of the apothecium. ×75.

P. Asci and paraphyses. The length of the latter does not greatly exceed that of the asci. ×500.

Q. Two types of abnormal asci frequently seen. In one type there are 4 abnormally large ascospores; in the other are 4 large spores and 4 very small or extremely aberrant spores. ×500.

R. Ascospores. ×500.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APPARATUS AND METHOD FOR OBTAINING STERILE FILTRATES OF BIOLOGICAL FLUIDS

EMERY R. RANKER[1]

INTRODUCTION

During a study of the physiology of disease resistance certain investigations were undertaken that involved obtaining sterile nonheated filtrates of the expressed juices of various parts of the host material involved. These filtrates were to be used in a comparative study of the effect of filtrates from resistant hosts and from susceptible hosts on the growth of the pathogene when cultured in those filtrates.

The number of hosts to be tested, the quantity of host material to be used, and the hundreds of sterile filtrates to be obtained made it imperative that any filtration apparatus used should meet certain definite requirements. These were: (1) The apparatus should be capable of producing absolutely sterile filtrates consistently when properly handled. (2) Once set up, it should not require further attention during the process of filtration until disconnected to obtain the sterile filtrate. (3) The apparatus should be constructed of parts that could be made in any laboratory by any one having some skill in glass blowing. (4) It should be compact, easy to disconnect to obtain the filtrates and to assemble for sterilization. (5) The receptacle for collecting the sterile filtrate should be constructed to facilitate subsequent transfer of the filtrate to various culture vessels without undue danger of contamination. (6) The apparatus should be so constructed as to permit sterilization in an autoclave after it is completely assembled, namely, so that but two operations are required to start the filtration process, (a) to connect to a source of vacuum and (b) to cover the surface of the filter with the juice to be filtered.

It is obvious that this sixth requirement and the large number of filtrates to be obtained would prohibit the use of agar, paraffin applied hot, and similar materials that frequently are recommended as suitable for sealing joints. Such substances, when so used, are unsatisfactory and it is advisable, when possible, to avoid them. The repeated use of heated paraffin to seal a joint adjacent to a porous filter surface ultimately renders that surface useless as a medium for filtration. This is true especially if the filter is alternately sterilized, even though the paraffin may have been carefully removed.

[1] Formerly Associate Physiologist, Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

A review of the literature revealed a dearth of described apparatus that could be used satisfactorily for this work. The apparatus used and described by McBryde[2] seemed to meet certain requirements, but the suction flask is rather complicated in construction and the calibrations are not sufficiently accurate. This apparatus makes use of the Chamberland-Pasteur filter. When uniformly sterile filtrates are desired, this has a decided advantage, as pointed out by McBryde, over the standard equipment consisting of a glass mantle attached to a Berkefeld filter that leads directly into a suction flask. McBryde, however, recommends the use of paraffin to seal the various joints which would include the joint between the filter surface and the vessel containing the liquid to be filtered.

The apparatus reported by McKinney[3] employs standard equipment used in connection with the Berkefeld type of filter with the addition of a "filter tube" to increase the efficiency of the filter. The recommended use of such joint-sealing materials as hot paraffin, however, as a means of adapting this filter tube to use with other than the Berkefeld type of filter, would prohibit the use of this apparatus for the work at hand. Furthermore, the Berkefeld alone is not reliable for the uniform production of sterile filtrates except under certain conditions. These filters having the same degree of fineness, vary widely in permeability, and for each filter it was found that there was a time limit for filtration beyond which sterile filtrates were not produced. It was decided, therefore, to devise a filtration apparatus for this work. The one here described proved to be completely satisfactory in the production of nearly a thousand sterile filtrates and has wide applicability.

THE APPARATUS AND ITS USE

The apparatus that was finally developed, after several attempts, and was tested by the production of nearly a thousand sterile filtrates, is illustrated in figure 1.

When properly set up the apparatus shown in figure 1 produces practically 100 per cent sterile filtrates from the same vacuum source and with no increase of time because the process of double filtration continues simultaneously. The first filtration is done by a Chamberland-Pasteur filter (A), of fineness "B," which connects to the T-shape side arm of the glass tube enclosing a Berkefeld filter (size 1 x 2 inches; fineness "w") through which a second filtration of the same juice is accomplished. The sterile filtrate thus continues through the system and is collected in the flask (D), which

[2] McBryde, C. N. Filtration experiments with *Bacillus cholerae suis*. U. S. Dept. Agr., Bur. Animal Indus. Bul. 113. 1909.

[3] McKinney, H. H. A method of increasing the efficiency of filter cylinders. Phytopath. 14: 585–586. 1924.

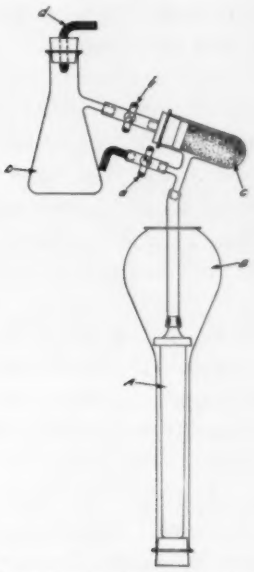

FIG. 1. Apparatus devised to obtain sterile filtrates of the juices of biological materials.

is of 250 cc. capacity but may be of any desired size. The flask (D) is an ordinary Pyrex Erlenmeyer flask into which a side arm has been sealed. The flask carries a bent-glass tube (d), plugged loosely with cotton to prevent possible contamination of the filtrates, and to this tube the source of vacuum is connected.

The assembly at (a) consists of a bent-glass tube filled with cotton and connects, through a short length of rubber tubing, to the T-shape side arm of (C). A screw clamp on the rubber tube is closed during operation. This assembly is used to obtain the filtrate contained inside the Chamberland-Pasteur filter (A) if needed. The filter is removed from the flask (B) and, while held in an inverted position, is shaken up and down rapidly to eject about 5 cc. of the contained liquid. This done, and with the filter maintained in an inverted position, the clamp at (a) is unscrewed to release the vacuum in the filter (A) very slowly. The sterile cotton in the bent-glass tube at (a) filters out contaminating organisms from the incoming air and the Berkefeld filter (C) holds the vacuum in the balance of the apparatus. After the vacuum in the filter (A) has been thus released the screw clamp at (a) is tightened immediately and the resulting vacuum causes the filtrate contained in the inverted filter (A) to run out and continue on through the apparatus to the flask (D). It may be necessary to repeat this procedure a second time.

The flask (B) is a Kjeldahl flask (500 cc.) with the neck stoppered and with a hole blown in the bulb end large enough to admit the filter (A). This flask is used to contain the juice to be filtered. It needs to be filled but once, the bulb acting as a reservoir. The neck of the flask fits closely around the filter (A) and maintains the filter at a high rate of efficiency due to the fact that only 25 to 30 cc. of juice in the neck of the flask will wet the entire surface of the filter. There are no joints that need to be sealed with agar or hot wax. All rubber tubing used in making connections is thick-walled ($\frac{1}{8}$ inch bore and $\frac{1}{8}$ inch wall) to withstand the external pressure during the process of filtration.

Before use, the assembled apparatus shown in figure 1, with the exception of the inverted Kjeldahl flask (B), is sterilized in an autoclave for 30 minutes at a pressure of 15 pounds. When setting up the apparatus but two operations are required, namely, to place the filter (A) into the inverted Kjeldahl flask (B) and to connect the apparatus to the source of vacuum through the bent-glass tube (d). During operation the clamp at (b) is open and the clamp at (a) is closed. Evacuation should be maintained at an equivalent pressure as near 30 inches of vacuum as possible.

When sufficient filtrate has collected in the flask (D) and it is desired to stop the process, (1) the clamp (b) is screwed down tightly, (2) the vacuum in flask (D) is very slowly released by breaking the rubber-tube connection on the bent-glass tube (d) after the source of vacuum has been shut off by a suitable clamp, and (3) the flask (D) is then disconnected from the remainder of the apparatus by removing the rubber tube from the metal-tube outlet of the Berkefeld filter (C).

The flask (D), which contains the sterile filtrate, after being thus disconnected, carries the bent-glass tube (d) filled with sterile cotton to prevent contamination of the filtrate. The side arm of this flask carries the short length of rubber tubing that is securely closed by the screw clamp (b). In this condition the flask (D) serves as a convenient and efficient means of transferring the sterile filtrate to such culture vessels or measuring devices as may be used. To accomplish this transfer, which preferably is done in a transfer room that has been steam-sterilized, (1) the rubber tubing on the side arm is removed, (2) the side arm is heated gently in a flame, and (3) the filtrate is poured out through the side arm into the culture vessels. This may be done either directly or into some suitable measuring device and from this into the culture vessels if it is necessary to measure the filtrate used.

This apparatus is adapted to being set up in series on the same vacuum line. A battery of apparatus so set up is illustrated in figure 2.

The efficiency of this apparatus through the use of the inverted Kjeldahl flask (Fig. 1, B) has been indicated. Its efficiency is increased by its

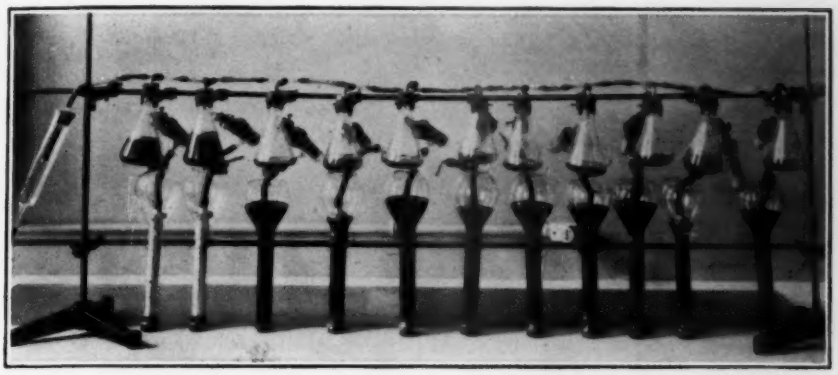

FIG. 2. Battery of filtration apparatus set up and in operation. The inverted Kjeldahl flasks (Fig. 1, B) are held in place by small copper wires twisted around the lower horizontal iron rod. Most of the weight of the apparatus is supported by the burette clamps around the necks of the flasks (Fig. 1, D). The vacuum line is extended by means of glass T-tubes connected together by thick-wall rubber tubing. All connections not subject to sterilization are shellacked.

general utility as a whole or in part. Any of the standard types of filters may be connected to the apparatus as the Chamberland-Pasteur filter (Fig. 1, A) is connected. Where only a single filtration is desired the filter may be connected directly to the flask (Fig. 1, D), thus taking advantage of the increased efficiency of filtration through the use of the inverted Kjeldahl flask, which, in its various sizes, is adapted for use with most filters.

The apparatus illustrated in figures 1 and 2 has been used to obtain more than a thousand sterile filtrates. The number of contaminated filtrates that developed has been negligible. At intervals it is necessary to replace the stoppers and rubber connections as repeated sterilization causes the rubber to lose its elasticity.

SUMMARY

An apparatus for the uniform production of sterile filtrates is described. It is of simple construction, of high efficiency as a medium of filtration, and of wide utility. The apparatus is readily adapted to the use of practically all types of filters without the use of such joint-sealing materials as agar or hot wax, which are so frequently recommended for such use.

A BRUSH TREATMENT OF MOLDY STAVES[1]

DOW V. BAXTER

The molding of staves has occasioned such severe losses throughout the South-Central and Southern States that mill owners have been forced to try various control treatments. Mill owners also have followed different prophylactic practices in the handling of the wood in the effort to lessen the possibilities of mold development. Some of these practices and the reasons for them are as follows: (a) By felling the timber in the winter when temperature conditions are not optimum for the rapid growth of mold, much molding of the staves is prevented. (b) Through immediate hauling of the logs or bolts to the mill, thus preventing the wood from being exposed to mold fungi in the woods. (c) By construction of dry foundations for bolts in the yard. (d) Through immediate sawing of all raw stock in the summer. Insect attack on timber felled in the summer causes serious losses in green wood. It is estimated that stave timber bolts and logs may be rendered worthless within three weeks after felling (from June to September) by insect attack. Felling timber in the winter avoids much of this loss. In the summer time bolts may become molded within a week. Rot, especially in gum, follows within a week of this blacking if optimum conditions for fungus growth are present. Most mill men cannot afford to have their yards filled with stored bolts during the spring and summer because of the rapid growth of mold during this season. (e) By the construction of suitable drying sheds which allow rapid seasoning of the staves. Since dry staves do not mold, these open sheds or buildings are ordinarily constructed so that they extend in a north and south direction. Usually the racks of staves are run east and west. This facilitates the drying out of the staves within a short time, after the wood has left the steam box.

Various chemical treatments have been tried with differing degrees of success in the effort to check molds and stains in wood.[2] Sodium fluoride, sodium bifluoride, sodium carbonate, and sodium bicarbonate have been used in treatments. Lime has been employed in the yards without any success. Mercuric chloride is probably one of the best antiseptics used to prevent mold in the steamed wood, but it cannot be applied to cooperage in which foodstuffs are shipped. Other chemicals are of doubtful value because they are ineffective or they may stain the wood or they may otherwise render it unfit for retention and shipment of foodstuffs.

[1] Contribution No. 14 from the School of Forestry and Conservation, University of Michigan.

[2] Howard, N. O. The control of sap-stain, mold, and incipient decay in green wood with special reference to vehicle stock. U. S. Dept. Agr. Bul. 1037. 1922.

Kiln-drying of stave wood has been found to be the most effective means of controlling mold, but the cost of installing a kiln is practically prohibitive even in the larger mills. The installation of a kiln in the smaller mills may represent an outlay of money greater than the cost of all the remaining equipment of the mill. There are additional objections to the drying of staves in kilns. Many mill operators object to the cost of fuel required to run a kiln. The wood which would be required to run the kiln is ordinarily sold and is depended upon as a source of revenue for the mill. Kiln-dried staves also are subject to warping. It is estimated that at least 10 per cent of the kiln-dried staves are so badly warped that they are rendered practically worthless. The remaining staves may be so badly warped that they are often degraded.

ECONOMIC IMPORTANCE OF MOLD IN STAVES

It has been estimated[3] that fungous stains in lumber cause an annual loss of over ten million dollars. Although mold has been considered of little importance in producing permanent discolorations in lumber, losses brought about by mold fungi in stave wood amount to thousands of dollars (Fig. 1, A and B). Little consideration has been given to moldiness in lumber because the molded surfaces can be so readily planed off in working up the wood. It can be seen readily that such small products as staves cannot be economically planed, even assuming that their dimensions would remain unaltered and that the staves themselves present a plane surface.

The losses caused by molds in staves vary with the kind of timber used and with the location of the mill. The observations recorded in this paper were made largely at the East Prairie Stave Company mill at East Prairie, Missouri. Red gum, the leading wood used in stave production, is most subject to molding in southeastern Missouri. Moldiness in elm, a species ranking next to gum in stave manufacture, places it second to red gum in susceptibility. Hackberry also may be placed in the same class with elm. It is, however, more subject to stain (blackening) than to mold. Sycamore is subject to a "rust," but this is not serious. Losses in maple staves are not appreciable, and ash very seldom molds. It is estimated that 60 per cent of the gum and hackberry staves and 10 per cent of the elm staves are damaged during the summer. When moisture and temperature conditions are most favorable for fungous growth (ordinarily between June and the last of September), mold may appear within three to five days after the staves are put out in the racks. These large losses are general in Arkansas, Mississippi, Tennessee, and Louisiana, as well as in southeastern Missouri.

In Mississippi and farther south the molding season is longer and greater losses are consequently suffered. It happens, however, that losses

[3] Hubert, E. E. The brown stains of lumber. The Timberman 27, No. 7. 1926.

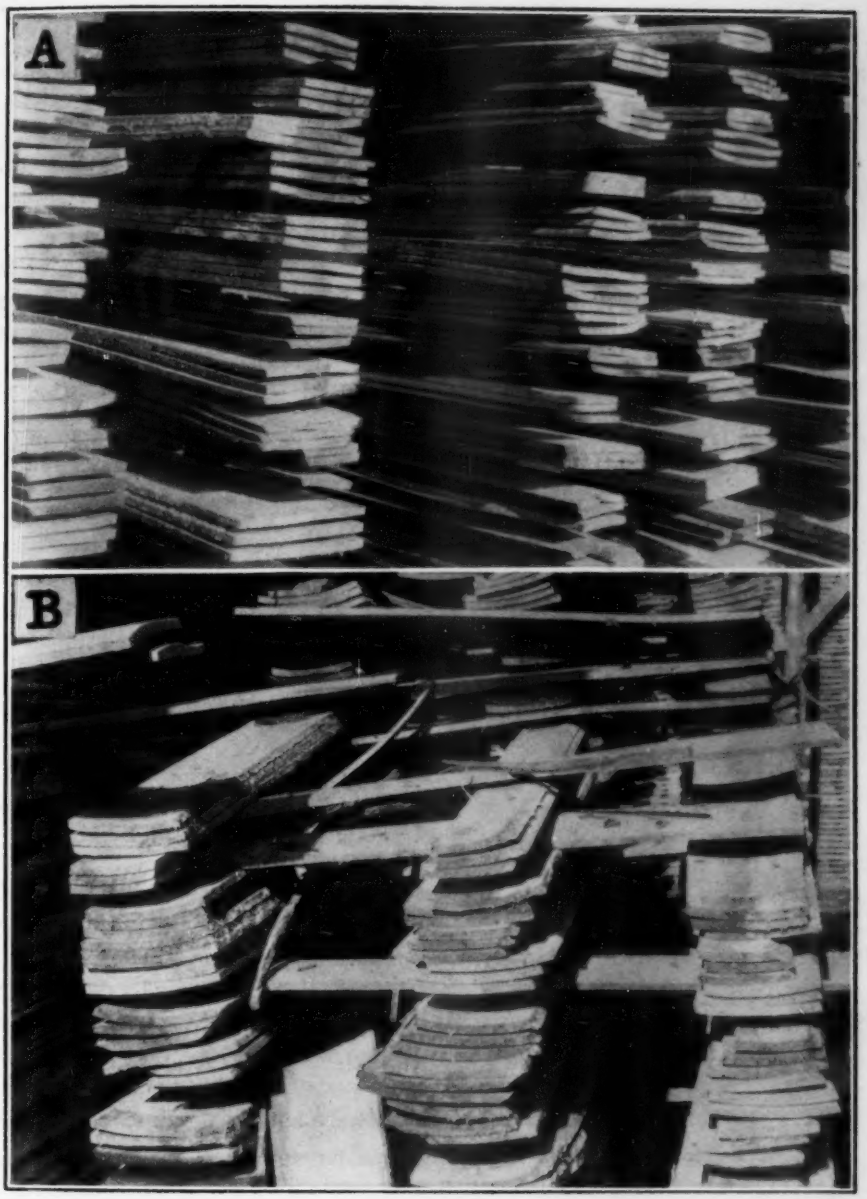

FIG. 1. A. Moldy staves, East Prairie, Missouri. (Roughened surface indicates moldy condition.) B. Moldy staves in stacks, East Prairie, Missouri. (East side.)

vary even within the same locality. At mills located only 30 miles apart, the loss caused by mold may be very severe in one mill yard and negligible in another. When losses do vary within a given region at different mills, differences in relative humidity are believed to be responsible. One mill yard, for example, at Water Valley, Mississippi, located in the river-bottom lands, where fog is frequent, is subject to mold; the other mill yard, at Batesville, is located at the edge of the river valley, back from the lower bottom lands, and is almost free from mold. The humidity of the atmosphere is undoubtedly lower in this latter locality.

Although molds, stains, and decay develop very rapidly in the bolts before they are converted into staves during the spring and summer months (Fig. 2), the rapid sawing of the bolts into stave wood ordinarily prevents

FIG. 2. Hackberry, elm, and two red-gum bolts in a yard at East Prairie, Missouri, for forty days. Bolts were bright when brought to the yard.

serious loss in this material. Unless the bolts are immediately converted into staves at this season, decay will follow the mold and the wood will be rendered worthless within a very short time.[4] However, as the mold itself develops on the ends of the bolts it produces little damage and causes little or no degrade in the product unless it penetrates deeply into the ends of the bolts. As the 32-inch bolts[5] are cut to 30 inches it is possible to saw off both ends. Therefore, bolts that have not been penetrated by mold to a depth greater than one inch on each end of the bolt are not damaged. Mold on the

[4] Boltwood decays sometimes very rapidly even during the winter and early spring. An exceptional example from Mississippi may be cited. Elm bolts cut in January and ricked in the open on high ground were moved to the mill during the last part of May. When the bolts were sawn into staves it was found that 100 per cent of them were worthless because of a "white rot." The trees were apparently sound at the time of felling.

[5] The bolts are procured in 32-inch lengths.

bolts and stave ends, however, offers sources of inoculum for the staves in the racks and may be the indirect cause for rapid mold development in the yards.

PRINCIPAL FUNGI CAUSING MOLDINESS IN STAVES

A number of fungi have been identified that cause decay in wood. Among these *Graphium* spp., *Aspergillus* spp., *Cladosporium* sp., and a number of species belonging to the genus Penicillium should be mentioned. In southeastern Missouri most of the damage is caused by species of the green mold, Penicillium. The so-called red mold causes very little damage.

THE BRUSHER

When stock cannot be treated chemically, either because of the partial or complete ineffectiveness of the treatment or because the product is to be used for shipping of foodstuffs, the operator suffers tremendous loss. When

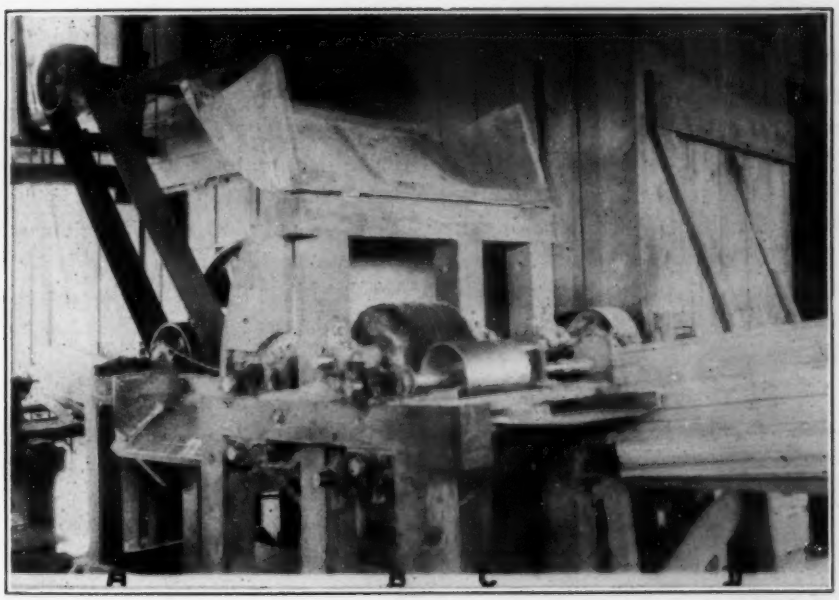

FIG. 3. Brushing machine, East Prairie, Missouri. A, drive shaft; B, steel brush; C, steel rollers; D, stave rack.

operating conditions prohibit the installation of a kiln or when the product warps badly because of such rapid seasoning brought about by kiln drying, use of the kiln in immediate practice does not seem to offer results of the most practical value.

It is believed that a brushing machine, designed by Mr. D. D. Baker,[6] of the East Prairie Stave Company, offers a method for salvaging much of the damaged stock in the mill yards. After the moldy staves have passed through the jointer they are moved to the brushing machine for treatment. Following is a description of this machine.

The brushing machine consists (Fig. 3) of two 10-inch, stiff steel-wire brushes, figure 3, B, so set that the brush tips barely touch. Two sets of steel rollers, C, are placed in front and also behind the two brushes. The speed of the machine is so set that the brushes have a peripheral speed with a ratio of 15 to 1 to the roller. This speed insures a sufficient brushing for the staves as they pass between the steel brushes. The brushes will take the staves at this speed as fast as one can feed them into the machine. The power for the brusher is furnished by the power plant used for generating the steam for the boxes in the mill.

SALVAGED STAVES

Brushed staves are placed in a grade known as "brushed number 1" (Fig. 4, A and B). This grade commands the same market price as bright number 1 staves. At present prices, moldy staves are worth $10.00 a thousand, while brushed red-gum staves are worth $13.00 to $13.50 a thousand. This saving is an important item to the mill operator when it is realized that, counting the time of the man needed to untie the bundles and feed the machine, the cost of brushing approximates only 40 cents a thousand. Table 1 indicates the amount of salvaged staves realized from this additional operation in the mill. The estimates given in this table are for the salvaging of staves by brushing during the molding season when conditions for mold growth are optimum.

TABLE 1.—*The salvage of moldy staves by the brush treatment*

Species (arranged in order of their degree of susceptibility to mold)	Percentage of moldy staves that can be salvaged by the brush treatment
Red gum	Approximately 40 per cent can be salvaged during the spring and summer. Sapwood gum begins to decay within 30 days
White elm	Practically 100 per cent will brush. This figure is particularly gratifying when one considers that elm is second only to gum in importance in the stave industry
Sycamore	Practically 100 per cent will brush

[6] The writer wishes to express his indebtedness to Mr. D. D. Baker for his cooperation and help during his visits at this mill.

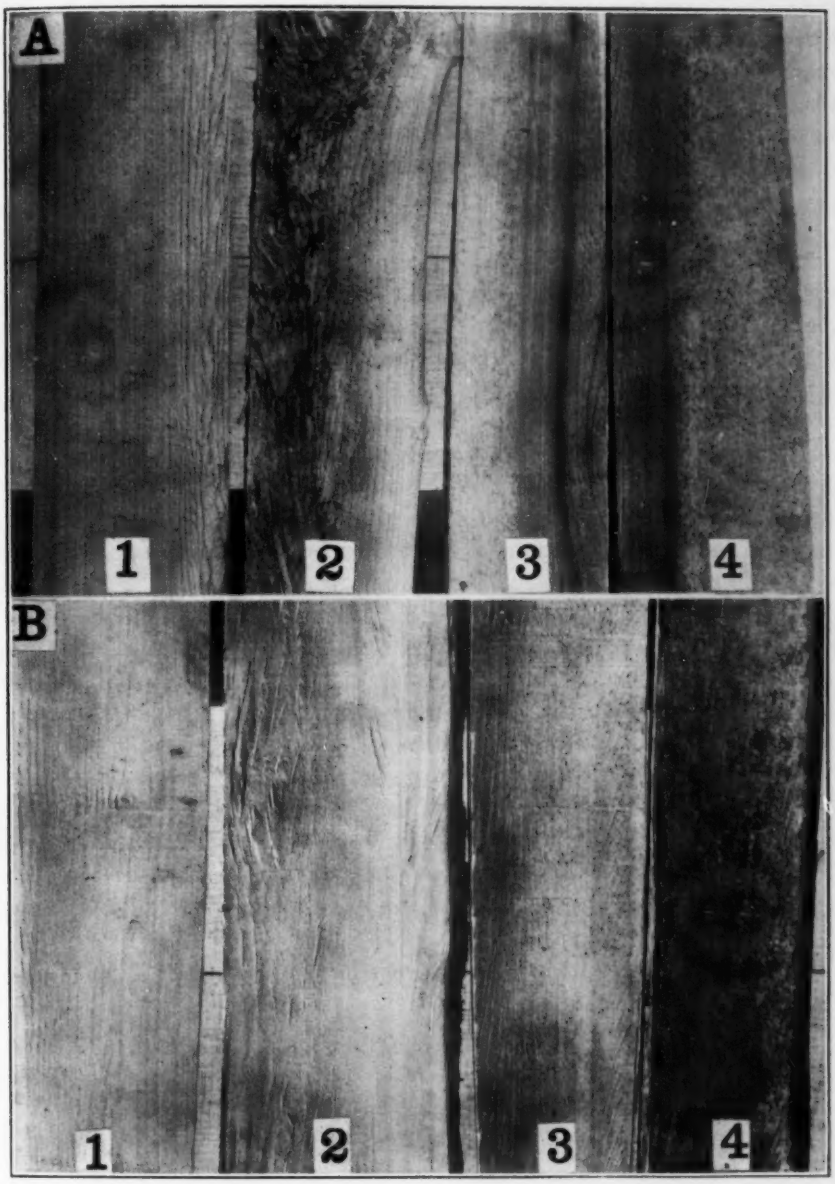

FIG. 4. A. White-elm staves, East Prairie, Missouri. 1, Bright No. 1; 2, Moldy elm (rust); 3, Brushed No. 1; 4, Moldy elm. B. Red-gum staves, East Prairie, Missouri. 1, Bright No. 1; 2, Blue-stained gum, stain in wood before made into staves; 3, Brushed No. 1; 4, Moldy gum.

As the staves are dry after they leave the brushing machine, no loss from molding occurs after the staves have been bundled. Blue stains, which usually appear in the woods before the bolts reach the yards, "fleck" stains, caused by Penicillium, itself, and "rust" are not removed by the brusher. The fleck stains left after brushing, however, do not prevent the staves from being placed in the brush number 1 grade.

CONCLUSIONS AND SUMMARY

1. Although stains, and particularly blue stains, in lumber have attracted much attention and have been the subject of numerous and long-time investigations in both Europe and the United States, very little information on the molding of wood is at hand. This is in part due to the fact that the molds generally have been regarded as superficial growths, readily removable by planing. The damage caused to staves by molding, however, amounts to an annual loss of thousands of dollars and a waste of valuable timber, as molds on staves cannot be removed by planing. It is, furthermore, difficult and often impossible to give them effective chemical treatment. Although staves are dried frequently in the kiln, there are several objections also to this treatment for stave timber.

2. A mechanical method is described by which staves can be brushed between steel brushes. This method insures a salvage of practically 100 per cent of the molded white-elm and sycamore staves. The number of red-gum staves that may be salvaged depends somewhat upon the season. Approximately 40 per cent of the red-gum staves, however, may be salvaged by brushing. These figures are believed to be particularly gratifying, as red gum is the leading wood used in stave production and white elm ranks second only to gum. The stave brusher here described is a very simple machine and can be installed without much added expense to the operator. The operating expense of the stave brusher approximates 40 cents a thousand staves.

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MODIFIED PROCEDURE WITH THE KEITT SINGLE-SPORE METHOD[1]

WALTER N. EZEKIEL

While using the single-spore method described by Keitt[2] the writer has tested various modifications and eventually developed a procedure that has proved exceptionally useful in isolating single-spore strains of many fungi, including species of Sclerotinia, Fusarium, Alternaria, Helminthosporium, Phoma, Chaetomella, Rhizopus, and Rosellinia. The details of the procedure are not new; but the combination not only retains the advantages of the original Keitt method in that it is simple, requires little special equipment, and is applicable to many kinds of spores, but also has the further advantages of greater rapidity and ease of operation.

CHANGES FROM THE ORIGINAL METHOD

The procedure outlined by Keitt is as follows: A dilution series is poured in petri dishes, in one of which a suitably located spore is selected under the microscope, usually after germination has rendered the sporeling easily visible. A special needle with a hollow, cylindric end (Fig. 1, *b*) is then used to cut out a disk of agar which includes the spore. This disk is transferred by a second special needle, with a flattened and twisted tip, to another petri dish for further growth.

The important change has been the substitution of a streak culture, in a petri dish of set agar, for the dilution series previously used. In plates of dilution series, spores were distributed at various depths vertically and in unknown positions horizontally throughout the agar. Microscopic search for suitably isolated spores was, therefore, exceedingly tedious. With the streak isolation, on the other hand, spores are distributed only at a definite depth in the agar and in streaks of definite width and need be sought only along these streaks. All the inoculum is to be found in one plane of observation with the 16 mm. objective. This has greatly reduced the time and energy necessary to find spores far enough apart in the agar to allow removal of individual spores in agar blocks.

A straight chromel[3] needle with a broad, rounded tip (Fig. 1, *a*) has been substituted for the needle with the twisted tip formerly used for the

[1] Published with the approval of the Director as Technical Contribution No. 88 of the Texas Agricultural Experiment Station.

[2] Keitt, G. W. Simple technique for isolating single-spore strains of certain types of fungi. Phytopath. 5: 266–269. 1915.

[3] Chromel (or nichrome) wire of B. & S. gauge No. 24 has been found excellent for the needles mentioned.

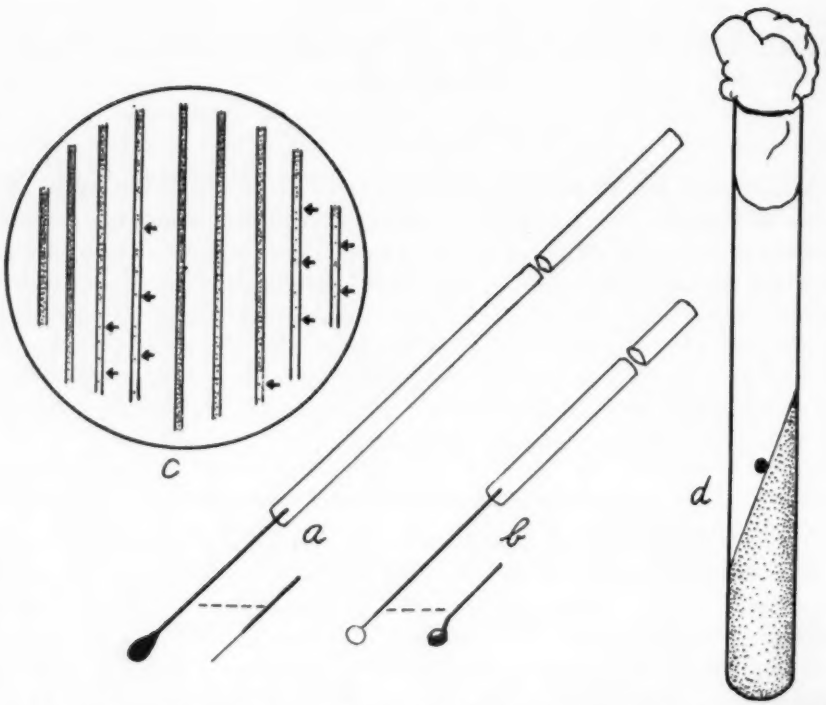

FIG. 1. Single-spore procedure. *a*, Top and side views of needle with spatulate tip; *b*, top and oblique views of needle with cylindric tip; *c*, diagram of distribution of spores in a streak culture, the arrows indicating regions in which spores might be selected; *d*, position of agar disk, containing the selected sporeling, after transfer to agar slant.

transfer of the agar disk. The straight needle is preferable when the disk is to be inverted as described below and also is useful in inoculating the streak plate. To prepare the two needles, the tips of two wires are first hammered flat. One tip is twisted to form the cylinder shown in figure 1, *b*, and the wire is mounted in a short handle 8 to 10 cm. long. The edges of the flattened tip of the other wire are smoothed, if necessary, with a file, and this wire is then mounted in a longer handle.

A further change is the use of agar slants rather than petri-dish cultures for the sporelings selected. By inverting the agar disk as it is transferred and placing the disk at the edge of the slant, it is possible to obtain almost as clear vision of the selected spore and of growth from it as if the transfer were to a petri dish. Advantages of use of the tube are the greater freedom from accidental contamination, especially when isolating slow-growing organisms, and the greater convenience of storage of tube cultures.

THE REVISED PROCEDURE

Preparation of the streak plate. The agar should be suitable for growth of the organism at hand but need not be extraordinarily clear. Potato-dextrose agar and oatmeal agar, filtered through absorbent cotton, have, after final sterilization, rather abundant, fine, granular precipitates, which have not hindered frequent use of these media. The granules aid in focusing on the surface of the agar, without obscuring vision of the spores scattered along the streaks. The consistency of the agar is of importance. It should be firm enough to permit the flat tip of the inoculating needle to make a definite scar in the preparation of the streaks but not be so dense as to make difficult the cutting out of the disks. The quantity of agar to be used per plate varies with the thickness of the glass bottom of the petri dish, since microscopic observation is through this to the opposite surface of the agar. Microscopic observation becomes more difficult as the depth of the agar increases, while manipulation of the agar blocks becomes easier. With the standard (95 mm. diameter) petri dish, 6 to 8 cc. of standard 1 per cent or 1.5 per cent agar per dish has usually been satisfactory.

The petri dish is flamed and the agar poured while both are hot, using the customary aseptic precautions. After the agar has cooled, a liberal amount of inoculum is taken up on the spatulate-tip needle, which is then drawn across the agar in a series of four or five parallel streaks. Two series of streaks are made in each dish when sufficient inoculum is available. Pycnidia, perithecia, or apothecia may conveniently be crushed in the droplets of water which condense on the cover of the dish and the resulting suspension then used in preparing the streaks. The broad tip of the needle is held flat against the surface of the agar and pressed into it hard enough to leave a mark visible macroscopically. This is done to aid in locating the streaks later, and such markings in the agar do not interfere with microscopic examination, except perhaps when working with unusually minute spores. The needle is rotated in the fingers very slightly at the beginning of each stroke across the plate, so that a portion of fresh surface touches the agar. As a result, each streak begins with a more or less crowded mass of spores but thins down to spores separated by increasingly greater intervals (Fig. 1, *c*). It is along the latter part of the streaks that isolated spores are found.

Selection of single spores. Except with large, dark spores it is best to defer selection until 16 to 24 hours after preparation of the plates to allow enough growth to facilitate observation as well as to prevent selection of nonviable spores.

The petri dish is examined through the bottom without opening it. First the 16 mm. objective is used to run along the streaks until an isolated spore-

ling is found. This is examined further with the 8 or 9 mm. objective to insure that only a single spore is at the center of the observed growth. If the sporeling appears satisfactory, a dot of ink is placed (with a fountain pen) directly over the sporeling. The petri dish can now, without danger of losing the place, be moved around to ascertain whether the space around the sporeling is actually free of other growth. After this, an ink ring is drawn around the original ink dot to indicate the clear working space around the spore. The plate is then turned with the top up and the agar disk cut around the spore.

Cutting the agar disk. The cylindric-tip needle is flamed, cooled, held with its center exactly above the ink dot, plunged down rapidly and immediately withdrawn, thus making a circular incision around the spore. The ink dot may now be removed from the bottom of the petri dish; and the cylindric agar disk now marked off may be examined microscopically, through the bottom of the dish, to insure that the sporeling selected is actually included in the disk and that no other growth is included in it.

Transferring the agar disk. The flat-tip needle is slid under the disk, which is then raised and transferred to an agar slant. To facilitate observation, the disk is placed with its upper surface against the glass at the edge of the slant but part way down the slant to insure sufficient moisture for growth. Since the spore was placed originally on the surface of the agar, it will now be quite close to the glass of the tube and may be examined usually not only with the 16 mm. objective but also with the 8 mm. objective. The rest of the disk should also be examined, as additional spores that were not observed in the previous view from below may possibly be found now in this surface view.

Further check on the monosporous nature of the culture is obtained by rapid microscopic examination of the agar disk during further incubation. All growth should be from the single selected sporeling.

SUMMARY

The following procedure has been found useful for single-spore isolation:

(1) A streak culture is prepared in a petri dish of set agar.

(2) The dish is inverted and a suitably isolated sporeling is selected under the microscope and its position indicated with a dot of ink.

(3) The dish is turned up again and a disk of agar including the sporeling is cut out.

(4) The agar disk is transferred to the edge of an agar slant.

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A RHIZOCTONIA DISEASE OF SWEET ALYSSUM[1]

PAUL E. TILFORD

In July, 1927, the writer's attention was directed to a disease of sweet alyssum, *Alyssum odoratum*, occurring in a garden in Wooster, Ohio. Sweet alyssum is commonly used as a border around beds of annual flowers. The plants are set close together, thus forming a dense, low, hedge-like border.

SYMPTOMS AND ETIOLOGY

The disease started in the lower portion of the plants, where the leaves and stems lay on the ground. These diseased parts first appeared water-soaked and looked as if they had been scalded. The disease progressed rapidly, rotting the leaves and causing them to shrivel up (Fig. 1). Defi-

FIG. 1. Sweet alyssum plant affected with Rhizoctonia, on left; healthy plant, on right.

nite lesions appeared on the stems and usually the portion of the plant above the lesion was killed. Leaves on the upper part of the plant appeared normal unless a large lesion occurred lower down on the stem. In no case were lesions noted on the main stem below the level of the soil.

[1] Published with the permission of the Director of the Ohio Agricultural Experiment Station.

Early in the morning or during rainy periods an abundance of a cob-web-like mycelium was visible on the diseased plants. Microscopic examination of this fungus showed it to have the morphological characteristics of Rhizoctonia. A Rhizoctonia was isolated from the diseased stems and leaves and grown in culture. Healthy plantings of sweet alyssum were inoculated with the organism and after 18 days (during this period there was considerable rain) the plants were badly diseased. The organism was reisolated.

Peltier[2] has reported a Rhizoctonia on sweet alyssum growing in pots in the greenhouse. He states that small lesions were formed on the stems near the ground. Teng[3] has recently described a Rhizoctonia disease of Lobelia which in many respects is similar to the disease of sweet alyssum reported here. Also, the brown-patch disease of grass, originally described by Piper and Coe,[4] shows similar characteristics.

The sweet-alyssum Rhizoctonia was grown on oatmeal and potato-dextrose agar at different temperatures and compared with other Rhizoctonias isolated from potato, aster, and chrysanthemum. Agar was poured in petri dishes to a depth of about 5 mm. Small bits of inoculum were transferred from 3-day-old tube cultures to the center of the agar plates. The plates were then placed inside paper bags and put in constant-temperature incubators ranging from 5° C. to 30° C. at 5-degree intervals. The plates were examined at 12-hour intervals and measurements made of the radial growth. Two plates were used with each organism at each temperature, and the two measurements were averaged.

The organisms isolated from aster and chrysanthemum grew at about the same rate. The sweet alyssum organism grew a little faster at 30° and at 15° than the other two. All three grew faster than the potato organism. This was especially true at 30°. All four organisms grew faster on oatmeal agar at 10° and 15° than on potato-dextrose agar at these temperatures. No growth occurred in any case at 5° C. The experiment was discontinued after 168 hours. The rate of growth of the four organisms on potato-dextrose agar is shown in figure 2.

The color of the mycelium of all four organisms ranged from white at the lower temperatures to dark brown at the higher temperatures. Zonation occurred only in the case of the organisms isolated from aster, chrysanthemum, and potato. The sweet-aylssum organism formed abundant brown to black sclerotia which seemed to pile up on each other, thus forming large irregular sclerotia.

[2] Peltier, G. L. Parasitic Rhizoctonias in America. Ill. Agr. Exp. Sta. Bul. 189. 1916.

[3] Teng, S. C. Rhizoctonosis of Lobelia. Phytopath. 19: 585–588. 1929.

[4] Piper, C. V., and H. S. Coe. Rhizoctonia in lawns and pastures. Phytopath. 9: 89–92. 1919.

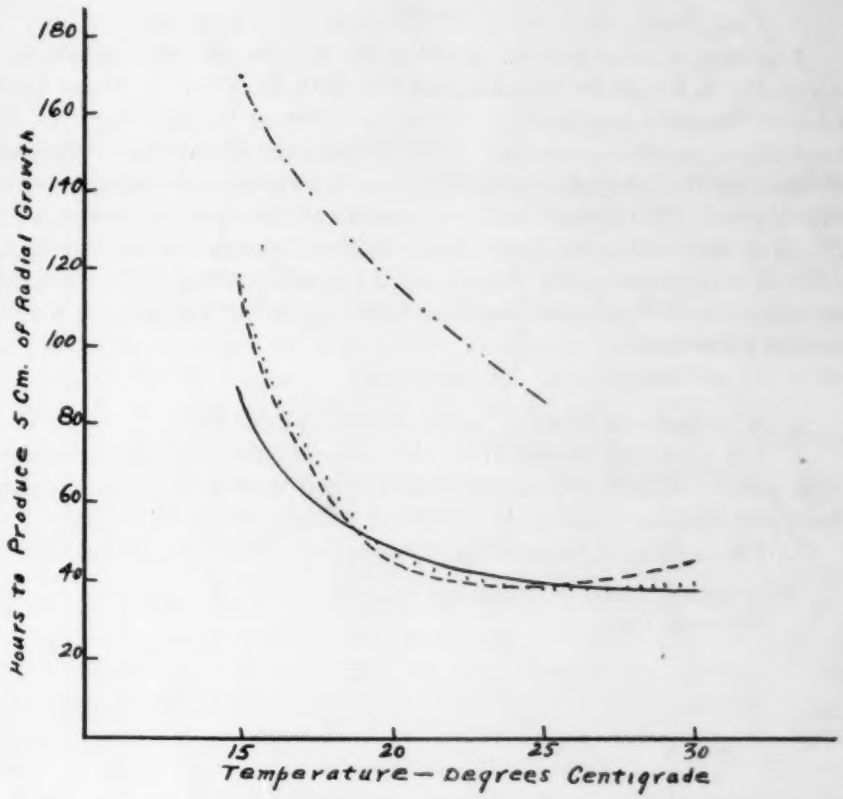

FIG. 2. Effect of temperature on rate of growth of different strains of *Rhizoctonia solani* on potato-dextrose agar

·· — ·· Isolated from potato.
——— " " sweet alyssum.
..... " " chrysanthemum.
– – – – " " aster.

While the sweet alyssum Rhizoctonia varies considerably from the potato Rhizoctonia, yet there are no morphological or physiological characteristics to suggest that it should not be classed as *Rhizoctonia solani* Kühn. Both Monteith and Dahl[5] and Peltier[6] have reported great variations in the growth characters of *Rhizoctonia solani* when isolated from different hosts and grown in culture. Peltier reports similar variations when different strains, isolated from the same host, are compared.

[5] Monteith, J., Jr., and A. S. Dahl. A comparison of some strains of *Rhizoctonia solani* in culture. Jour. Agr. Res. 36: 897–903. 1928.

[6] *Loc. cit.*

CONTROL

Plantings of sweet alyssum in which the disease was very serious were sprayed with 4–6–50 Bordeaux mixture on July 25, 1927. A second treatment of Bordeaux was made on August 1. Parts of the planting were left nonsprayed to serve as checks. After 18 days the disease was completely checked on the sprayed plants. They were sending out new shoots and growing well. The disease had progressed in the nonsprayed plants and at this time they were practically dead. Sweet alyssum can be thoroughly sprayed without drenching the soil and no ill effects should follow from an accumulation of copper in the soil, as is the case when Bordeaux is used to control brown patch.

SUMMARY

1. A Rhizoctonia disease of sweet alyssum is described.

2. The organism is compared with *Rhizoctonia solani* Kühn isolated from potato and with Rhizoctonia isolated from aster and chrysanthemum. The sweet alyssum organism is a strain of *Rhizoctonia solani* Kühn.

3. The disease can be controlled by spraying with Bordeaux mixture.

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NOTES ON *PHYLLOSTICTA RABIEI* ON CHICK-PEA

RODERICK SPRAGUE

INTRODUCTION

Following the same general lines as those pursued in the recent work on diseases of legumes caused by Ascochyta,[1] the writer was able through materials and cultures sent by Dr. D. Atanasoff from Bulgaria to determine that the common disease of chick-pea, *Cicer arietinum* L., caused by *Phyllosticta rabiei* (Pass.) Trotter, is distinct from any Ascochyta on legumes. This has been clearly shown, in part at least, by Trotter,[2] but his work does not seem to be widely accepted. In the light of recent studies by the writer and others it is thought advisable to publish this note.

Although Trotter found no trace of septate spores in the herbaria he examined, this was not true of the writer's study. Without reviewing the literature on the subject it may be mentioned that many texts list the chick-pea as a host for *Ascochyta pisi* Lib. Trotter examined all of the historic collections and concluded he was dealing with a Phyllosticta. An examination of several French and Italian collections and a study of the fungus on inoculated plants convince the writer that faint septations, up to about 5 per cent of the total, are commonly, though not always, present. These septations usually are visible only with the aid of an oil-immersion lens. Many spores show a constriction at their equator. In spores from inoculated plants a gradual formation of the oil-like contents into two separate masses is noted with the occasional constriction, sometimes resulting in a cross wall.

COMPARISON OF SYMPTOMS

A comparison of mature aerial lesions produced by *P. rabiei* with those produced by *Mycosphaerella pinodes* and *A. pisi*, respectively, is given in table 1.

COMPARISON OF CULTURAL CHARACTERS

Tissue transfers on potato-dextrose agar (1 per cent dextrose), in test tubes under ice-box conditions, show a grey, felty growth with a small amount of a cream color, fluffy mycelium. Pycnidia develop in profusion at the top of the slant or along the sides next to the glass and exude pale pink spore masses. At first the medium turns opalescent and later becomes nearly black. These cultural characteristics contrast rather strikingly with

[1] Sprague, R. Host range and life history studies of some leguminous Ascochytae. Phytopath. 19: 917–932. 1929.

[2] Trotter, A. Riv. Patol. Veg., n. s. 9: 105–114. 1918.

TABLE 1.—*Comparison of mature aerial lesions produced on legumes by Phyllosticta rabiei, Mycosphaerella pinodes, and Ascochyta pisi, respectively*

Name of fungus	Characteristics of lesions			
	Color	Zonation	Border	Pycnidia
P. rabiei	Mottled brown to deep tan	2–3 (rarely more) wide irregular bands	Vague to prominent (red)	Very obscure
M. pinodes	Dark brown	Numerous	Vague	Obscure
A. pisi	Light tan	None	Prominent (red brown)	Prominent

the pink, fluffy mycelia and carrot-red pycnidial spore masses produced under similar conditions by *A. pisi.*

Cultures of *P. rabiei* made by spreading spore suspensions in water on the surface of pea-soup agar show many acervuli and pycnidia exuding small flesh-color spore masses that run together and often nearly cover a plate. Scarcely any fluffy mycelium is developed. Often interesting tentacle-like patterns of pycnidia radiate from several central areas on a plate.

In similarly produced cultures, *A. pisi* forms brighter, pink to carrot-red spore masses. Often these are fewer and larger and accompanied by a certain amount of evanescent, fluffy mycelium.

Compared with *M. pinodes* under similar conditions both of tissue transfers and of plate cultures from spore suspensions, *P. rabiei* shows a far greater tendency to fruit and has a lighter mycelium with little, if any, of the dark brown color of *M. pinodes.*

RESULTS OF ARTIFICIAL INOCULATIONS

The method of inoculation was the same as that used in former work, namely, young plants were sprayed with spore suspensions in water. Incubation was in a spray chamber and further incubation in a moist location. Reisolations were made where lesions were obtained.

The chick-pea organism showed negative results on several varieties of the garden pea, *Pisum sativum,* on *Vicia villosa, Lathyrus odoratus, Dolichos lablab, Lens ervum,* and two varieties of *Phaseolus vulgaris.* On the chick-pea water-soaked lesions appeared after five days. A few days later all but the most woody portions of the aerial parts of the host were dead and brown. Pycnidia developed in great profusion. This virulent blighting is the same type as seems to be common in Europe where

its scourge-like nature has attracted scientists since the days of Theophrastus and Pliny.

Inoculations on chick-pea with *A. pisi*, isolated from the garden pea, showed a doubtful tip injury to the chick-pea. In these inoculations strains of *A. pisi* both from the United States and Bulgaria were used.

In recent work by the writer[3] it was shown also that *M. pinodes* could cause severe foot-rot injury to the chick-pea, as could *A. pinodella* L. K. Jones. In the present study one inoculation on the aerial parts of chick-peas gave doubtful infection. The amount of work done was insufficient to determine definitely if *M. pinodes* would severely injure the aerial parts of the chick-pea.

DISCUSSION AND CONCLUSIONS

Everything considered, including morphology, it is clear that *P. rabiei* is distinct from *A. pisi*. Its relation to *M. pinodes* is closer. In shape of pycnospores, characteristics of pycnidia, and in pathogenicity, the two have some similarities. However, the nearly total lack of septation in pycnospores, differences in incubation period, difference in virulence on aerial parts, differences in host symptoms, the absence of a perfect stage in *P. rabiei*, and rather striking differences in cultural characters on agar make the two distinct. That *M. pinodes* may be found on the chick-pea in nature is highly probable, especially as a parasite producing foot rot.

The position of the chick-pea organism in the genus Phyllosticta is not so definite as Trotter assumed it to be. He and the writer agree, however, that there may have been some past genetic connection with Ascochyta. That the disease of chick-pea caused by *P. rabiei* must be dealt with as a problem distinct from that of those diseases caused by *A. pisi* and *M. pinodes*, respectively, is definitely shown.

This study was made at the University of Cincinnati subsequent to work for the doctorate under the advisory direction of Dr. O. T. Wilson. The writer is also indebted to Mr. Harry Muegel for translation of the extensive Italian literature.

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[3] *Loc. cit.*

BOOK REVIEW

Seymour, Arthur Bliss. Host index of the fungi of North America. 732 pp. Harvard University Press, Cambridge, Mass. 1929.

This book constitutes another outstanding contribution of Harvard University to those phases of botany especially pertinent to plant pathology. Its value is derived not only from the fact that a large part of a lifetime of labor has been devoted to its preparation, but from the skill and thoroughness with which a vast literature has been handled. It is the seemingly impossible dream of many a youthful mycologist brought to realization. Its dedication to the memory of William Gilson Farlow is at once a worthy tribute and a reminder of earlier associations. It recalls the fact that the Farlow herbarium and library must always continue of inestimable value to American mycology. It will also remind some of us that modern plant pathology in America began with the return of Farlow from de Bary's laboratory in the mid-seventies to inaugurate his epochal studies on black knot and other American plant diseases at the Bussey Institute. The titles mycologist and plant pathologist were synonyms in the early days of our profession. This usage is met today in British literature. Perhaps this may permit the reviewer, as one who has favored the modern trend toward the physiological approach in phytopathological researches, to stress the attendant danger that our younger professional recruits neglect their mycology.

The present work should therefore be a frequent reliance to the present-day plant pathologists, as was the first edition, the Farlow-Seymour Provisional Host Index of over 40 years ago, to those then exploring our fields for parasitic fungi. Pertinent statements from the first and this second index merit quotation. From the first edition: "Believing that an approximately complete list of our parasitic species and their hosts would aid materially in the advance toward a more accurate study of our mycological flora and would lessen the amount of indiscriminate species making which has already become a serious evil, the present index, the result of work extending over several years, has been prepared for publication." From the second edition: "The primary object of this work is to indicate, so far as recorded in the literature, for each host plant, all the fungi known to grow upon it and for each fungus all the hosts upon which it grows." In addition to their main purposes as indicated above, these scrupulously exact lists will, perhaps for years to come, serve as the most universally reliable American guide in mycological nomenclature. Their convenience will be felt in three respects—inclusive synonymy, correct spelling, and usage in

species capitalization. The author explains that he has decapitalized species names "whenever possible." The conservative principle of using capitals for those derived from personal and generic names is, however, followed. The reviewer believes that American botanists should follow the practice of the zoölogists in decapitalization of all species names. But for those who do not, this list will serve as a reliable basis of good usage. That it is practically impossible, however, for anyone to follow the rules of partial capitalization consistently is shown by the occasional deviations—*e.g.*, p. 368, "*Labrella Pomi*," "*Cylindrosporium pomi.*"

The inclusiveness of this index and the labor involved in its preparation are obvious when one notes that its 717 pages list some 80,000 names of hosts and fungi. The growth of a generation in American mycology is further indicated by the fact that the earlier edition of 213 pages contained only 23,000 or somewhat over one-fourth as many names. The usefulness as well as magnitude of the undertaking is again brought home if one examines the length of the list of fungi which may be recorded as occurring on almost any widely distributed cultivated plant. For example, those on the common apple (*Pyrus malus*) occupy nearly 5 pages and include some 340 named organisms. For each of some 75 of these, 2 to 8 names are listed as synonyms. As to the vexed questions of further unrecorded synonymy the author wisely indicates that "it is not the function of this work to solve botanical problems," although it must "present problems to be solved by others." "Each fungus name stands on its own merits, and the compiler has not changed it by substituting or adding a name more correct or better understood." The author regretfully explains that this list does not follow the plan of the earlier work in arranging all synonyms in chronological sequence, thus giving the history of the name.

The reviewer heartily endorses the statement that "no pains have been spared to make this index as complete and accurate as possible." This book should, therefore, be on the reference desk of every mycological and phytopathological library and laboratory. The author and his institution, Harvard University, deserve our congratulations and thanks on the completion and publication of this monumental undertaking. May we hope that it will sometime be followed by the complementary publication of the completed Bibliography of North American Fungi of which the first volume under Farlow's leadership and the patronage of the Carnegie Institution raised such great anticipations.—L. R. JONES, University of Wisconsin, Madison, Wis.